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ABSTRACT

A computer based diagnostic system to assist educators in the assessment of learning disabled children aged 8 to 10 years in the area of reading is described and evaluated. The system is intended to guide the diagnosis of reading problems through step by step analysis of available data and requests for additional data. The system provides a diagnostic report of its findings including areas and skills which require remediation or further assessment. The model on which the educational diagnostic process is based is the McLeod Educational Diagnostic Model consisting of four stages: retrospective, definitive, analytic, and prescriptive. Within each stage, three levels are considered--basic educational skills, psychoeducational skills, and noneducational factors. The system is intended to be used by teachers of regular classrooms or of resource rooms who have some familiarity with standard diagnostic procedures. The programing language LISP and a DEC 2060 computer were used to develop the program. The system was evaluated by comparing machine diagnoses to human diagnostic reports. This required encoding of the human diagnostician reports in terms of the expert system's descriptors and descriptor classification scheme. Results indicated that the export system's diagnoses were accurate, often providing more detailed information than human reports. Human reports often contained subjective impressions of child attitude and deportment not in the computerized reports. The system is thought to be appropriate for extension into mathematics and spelling, into other age ranges, and for use on microcomputers. Much of the report consists of four appendixes containing definitions of terms, an example of the system's performance, experimental data, and the encoded control structure. (DB)

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Computer-Guided Diagnosis of Learning Disabilities: A Prototype

by

Marlene Jones Colbourn
University of Saskatchewan

82-8

COMPUTER-GUIDED DIAGNOSIS OF LEARNING DISABILITIES: A PROTOTYPE

Submitted in partial fulfilment of the requirements
for the degree of Master of Education in the Department
for the Education of Exceptional Children, University
of Saskatchewan.

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ABSTRACT

When a child is experiencing learning difficulties, educational assessment should be undertaken as quickly as possible. The exact nature of the child's difficulties must be determined in order to plan an effective remedial program. Whenever possible, the diagnostic process should take place within the regular school environment, performed by the regular classroom teacher or the resource room teacher. Unfortunately, the child is often referred to an external agency for assessment, with no initial screening undertaken prior to referral. Moreover, it is often a lengthy wait before the specialist is available; this is especially true in rural or remote communities.

The main purpose of a computer-based diagnostic system is to assist educators in the assessment of learning difficulties, and hence to facilitate educational diagnosis within the regular school environment. The system guides the user through the various stages of diagnosis, from the initial screening through to a prescription. At each stage, the system analyzes the available data and suggests an appropriate next step. The teacher or diagnostician performs the required task, such as obtaining the requested data, or administering the appropriate test, and supplies this information to the system. After this new data is assimilated and analyzed, the system suggests the next step, and so on. Eventually, the system provides a summary of its diagnostic findings along with a suitable prescription.

This thesis examines the potential and feasibility of computer-guided diagnosis of learning difficulties. To demonstrate the latter, an expert system is developed to guide the diagnosis of reading problems; an expert system is an automated consulting system which provides the user with expert advice within a particular domain. The system designed and implemented here, guides the diagnostician through the various stages of educational diagnosis. The expert system provides a diagnostic report of its findings, including areas and skills which require remediation or further assessment.

In order to evaluate the performance of the operational system, previous diagnostic cases are employed. The system's findings are compared to those of human diagnosticians. These test cases demonstrate that the expert system's diagnostic reports tend to be both more accurate and more extensive than those of human diagnosticians. The success of the current system establishes that computer-guided diagnosis is feasible. Furthermore, it suggests that such guidance is advantageous when the diagnostician is inexperienced.

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CHAPTER ONE

INTRODUCTION

1.1 Computers within the Schools

Many schools throughout the United States and Canada now have access to computers; in the majority of cases, the schools have acquired microcomputers. The role of the computer within the classroom is varied. Computers can be employed for record keeping, for fun and games, to teach computer literacy, to teach programming concepts or particular programming languages. Furthermore, they can have a major impact through computer-assisted instruction (CAI). Most educators are familiar with these uses of a computer. Yet there is another important potential role for computers in the classroom: the diagnosis of learning difficulties.

The reader may be dubious. Too often educators have been told that computers will revolutionize education. Although they have had an impact, it has been far short of the promised revolution. Potential skepticism may be reduced by examining the current state of CAI.

Researchers within the field of computerized instruction have developed many terms to indicate the extent and role of the computer's involvement. For example, one encounters terms such as computer-assisted instruction/learning, computer-based instruction, computer-managed instruction. The most common, computer-assisted instruction (CAI), is employed here in its most general sense: the use of computers within a teaching environment, such that the student is directly interacting with the machine.

The conventional role of computers within the classroom is little more than automated programmed instruction. Generally, the student is placed at a computer terminal and frames of questions, usually multiple-choice, are presented. The pupil has little or no control over the content of the lessons nor can he/she ask the system for guidance or advice. Upon completion of a unit, the problems are automatically corrected, and if errors have been made, supplementary frames are presented. Such a system provides a useful means of identifying a student's weak subjects or skills; with this information, the student can be drilled endlessly in these areas. At present, there are thousands of drill-and-practice computer programs available for teaching standard school subjects.

Although such programs can be useful, they are not what researchers initially had promised. CAI should mean individualized instruction, tailored to the child's particular strengths, weaknesses, needs and interests. Not surprisingly, many educators and researchers are disappointed with much of the commercially available CAI.

Research within the field of Artificial Intelligence has shown that truly individualized computer-based instruction is possible. Current technology and expertise is such that appropriate CAI systems can be implemented. Their development, however, is costly in terms of time, research funds and personnel.

In addition to employing computers to impart knowledge and information, students should have the freedom to explore particular subjects. This can be accomplished by letting the child ask questions or by allowing interaction with a simulation of the situation in question. This type of CAI is known as generative CAI, since it is actually able to generate lessons rather than just retrieve those stored by an instructor. Serious research on generative CAI was first undertaken by Carbonell (1970). SOPHIE (Brown, Burton & Bell, 1975), an instructional system which helps students design electronic circuits, was implemented with this idea in mind. SOPHIE uses its built-in "intelligence" to evaluate the student's answers and, if necessary, construct appropriate counter-examples. Other systems have been designed with the emphasis on problem-solving (Barr, Beard & Atkinson, 1976). In such an environment, the student attempts to solve problems with guidance and advice from the system. The computer gives hints, corrects errors and evaluates progress.

Ideally, we want to offer the student not only a wide variety of programmed curricula, but a system which is adaptable to individual needs. In fact, flexibility is an essential feature if computers are to be successfully employed by exceptional children.

Within the past decade, researchers have developed many excellent CAI systems for children with special needs. Within all areas of exceptionality there has been success. Unfortunately, many of these systems are still in the pilot stage. Two promising projects designed to assist in teaching reading skills have been developed in Edinburgh, Scotland, and the University of New Hampshire.

At the University of Edinburgh, Howe and colleagues (Howe, 1979; Howe, Beattie, Cassels, Johnson & Anderson, 1978) have developed a computer-based system to teach word attack skills using a phonic approach. Children are taught consonants and vowels by naming familiar objects and associating the unknown letter with the uttered sound. The computer controls a slide projector and a pressure-sensitive screen. A picture of a familiar object (which the child can already name), such as a cat, is projected onto the screen, along with the letter c in the initial word position, e.g. 'c__'. The child says aloud the name of the object, associating the initial sound with the letter shape. Variations of this task are then presented. For example, when the familiar object is presented, the child must select the initial consonant from two or more alternatives. In another task, the initial consonant is given, along with two or three known objects; the child must choose the correct object. In each exercise the child indicates his/her selection by pressing the area of the screen containing the picture or letter. When an incorrect response is made, two types of information are provided. The correct choice is demonstrated. Secondly, the child's incorrect answer is explained. If the student selects an inappropriate picture, e.g. a dog for the letter c, the system demonstrates that dog corresponds to the letter d. Throughout the instruction, the computer controls the presentation of letters and choices, taking into account the child's level of mastery of each.

Another successful approach to teaching reading is through computer animation. Researchers at the University of New Hampshire have developed the Computer Animated Reading Instruction System (CARIS) (Geoffrion & Bergeron, 1977). Instead of starting with the recognition of individual letters CARIS first presents five common nouns. The child has to choose one by touching the screen with a light pen. The words then disappear to be replaced by a picture representing the selected word. On the left of the screen, five verbs appear. When one of these is selected, the figure on the screen acts out the intended meaning of the verb. After the animation is completed, the noun list reappears to allow a new selection. When these words are mastered, additional nouns and verbs are incorporated. Furthermore, the selection of words can be tailored to the individual's interests and skill level. After the child is proficient in forming simple sentences, the spelling phase is introduced. The light pen response for choosing words is no longer accepted by the computer. Instead the pupil must spell the desired word.

CARIS' effectiveness for teaching reading to exceptional children is still being evaluated. Children with a variety of disabilities, including deafness, mental retardation and learning disabilities, are presently taking part in the project. Although the studies are incomplete, children have already demonstrated that CARIS is both easy to operate and enjoyable. Unfortunately, the selection of words is still very limited.

Development of quality software is expensive in terms of both time and money. It is, however, being done. Furthermore, recent research in Artificial Intelligence has demonstrated that computer systems can be developed to provide users with expert advice in a variety of fields. Collaboration of educators and computer scientists has resulted in the expertise to develop a computer system capable of guiding an educator through the various stages of diagnosing learning disabilities.

1.2 Expert Systems

A computer system to provide expert advice on educational diagnosis is not currently available to teachers. However, corresponding systems have been developed in other fields, most notably medical diagnosis. An automated consulting system designed to provide the user with expert advice within a particular subject area is termed an expert system. The system employs the knowledge encoded in its software to aid or advise the user. In order to do this, a substantial amount of information concerning the given domain, the techniques and procedures employed within the area must be encoded. This data, which represents the human experts' knowledge, is employed by the system to advise the less experienced user. For example, an expert medical system might guide an inexperienced intern by asking appropriate questions. The intern would enter the answers into the computer until sufficient data had been collected for a diagnosis. For a field as large and varied as medicine, the scheme is complex.

Expert systems have been developed for general use in a variety of areas, with many others currently being designed and developed. Probably the best-known is DENDRAL, which determines the chemical structure of complex organic molecules (Buchanan & Feigenbaum, 1978; Feigenbaum, Buchanan & Lederberg, 1971). For a small number of molecular families for which the system has been given specialist's knowledge, DENDRAL's performance is both faster and more accurate than that of human experts. The DENDRAL system is currently in everyday use at Stanford University (Feigenbaum, 1979).

Within the field of medical diagnosis, there exist many computer-based systems designed to aid the user with this complex task. As early as the 1960s, computer programs were being development to aid clinicians with the classification of psychiatric problems (Spitzen & Endicott, 1968, 1969; Sletlen, Altman & Ulett, 1971; Overall & Hollister, 1964;

Fleiss, Spitzer, Cohen & Endicott, 1972). Unfortunately, the imprecision of clinical psychiatric diagnosis makes it difficult to judge the effectiveness of these systems. There are, however, several very successful medical expert systems. MYCIN (Shortliffe, 1976) diagnoses blood and meningitis infections and recommends appropriate drug treatment. Although MYCIN has not been evaluated within a clinical setting, a panel of judges felt MYCIN's performance was appropriate in 90% of the test cases. Other medical areas for which diagnostic expert systems have been developed include internal medicine (Pople, 1975, 1977), glaucoma (Weiss, Kulikowski & Safir, 1977), digitalis therapy (Swartout, 1977), cancer treatment (Shortliffe, Scott & Bischoff, 1981), and pulmonary function (Feigenbaum, 1979). For each of these systems, expertise is restricted to one area or subarea of medicine. A more advanced medical system, CADUCEUS -- currently being developed at the University of Pittburgh -- is intended to handle diagnosis within several medical fields.

Expert systems are by no means restricted to chemistry and medicine. Systems have been built to aid geologists in evaluating mineral sites (Duda, Gaschnig, Hart, Konolige, Reboh, Barrett & Slocum, 1978; Gaschnig, 1979), to teach geography (Carbonell, 1970), to detect students' algorithmic arithmetic errors (Brown & Burton, 1978), to detect computer faults (Bennett & Hollander, 1981), to assist in the design of complex computer chips and large computer systems themselves (Business Week, 1982). For further information regarding current expert systems and related technology, the interested reader should refer to (Buchanan, 1981; Hayes-Roth, Waterman & Lenat, 1982; Michie, 1979).

1.3 Overview of Thesis

In the remainder of this thesis, the feasibility of an expert system to guide the user through the various stages of diagnosing learning difficulties is examined. The purpose of such a system is to provide the teacher with expert advice on how to proceed from an initial suspicion that the child is experiencing problems through to developing a prescriptive treatment program.

Chapter 2 discusses the long-range role such an expert system can play within educational diagnosis. However, due to limited resources -- time, research funds, and personnel -- the system which has been designed and implemented in the present study is a fraction of this ultimate goal. Despite these restrictions, this thesis will test and support the following hypothesis:

> Hypothesis: Within the subject area of reading, there is no substantial difference between the diagnoses produced by the expert system and those of human diagnosticians.

Details concerning the design of our expert system are presented in Chapter 3. Chapter 4 contains a discussion of implementation, including instructions on the use of the system. In order to evaluate the performance of the operational system, the system's diagnostic findings are compared to those of human diagnosticians. The method and results of this comparison are presented in Chapter 5. The final chapter contains a discussion of the current impact of the developed system, its limitations, and possible directions for future research. The thesis also includes the following appendices:

Appendix A: definition of terms

Appendix B: sample computer listings to illustrate the execution of the expert system, the resultant diagnostic report and the global database

Appendix C: the experimental data, illustrating the comparison of the system's performance to that of human diagnosticians

Appendix D: the system's control structure and production rules, encoded in the programming language LISP

Appendix E: documentation for summarizing information from the School Report and the Parent Questionnaire (formerly, the Dyslexia Schedule)

CHAPTER TWO

AN EXPERT SYSTEM FOR EDUCATIONAL DIAGNOSIS

2.1 Educational Diagnosis: The SEECC Model

Before discussing the potential role of an expert consulting system within the field of educational assessment, the following questions must be addressed:

- who will be carrying out the diagnosis?
- where?
- what is the diagnostician's level of expertise?
- what assistance and resources are available to the diagnostician?

These questions can be answered by examining the SEECC (Standards for Educators of Exceptional Children in Canada) Model (Committee on Teacher Education and Professional Standards, 1971), which has been adopted in many areas of Saskatchewan and elsewhere.

Diagnosis generally begins within the regular classroom, as it is here that the child's learning difficulties are first suspected. The teacher is constantly evaluating each child's progress, identifying difficulties and setting appropriate educational goals and objectives. In some cases, the teacher may feel that additional advice is required in order to ascertain the true nature of the child's problems and to establish a suitable remedial program. In such instances, the resource room teacher is consulted. Even so the child need not be removed from the regular classroom. If appropriate instructional objectives still cannot be set and achieved, the resource room teacher must assume a more prominent role; this generally involves removing the child from the regular classroom, at least on a part-time basis. The majority of children experiencing learning difficulties can be dealt with at this level. There are cases, however, in which community resource personnel, such as doctors, psychologists and other specialists, should be consulted. Children with the most severe problems might be removed from their regular school environment and placed in a Learning Assistance Centre class. This may be either a short-term or a long-term placement.

Figure 1 illustrates the possible levels and locales at which educational assessment may take place. The child is removed from the regular classroom only if instructional objectives cannot be met within this environment. As far as possible, assessment should take place within the regular school environment. Even if the child is subsequently withdrawn for further assessment, the initial diagnosis should provide the consultant with basic information. The entire procedure must be efficient in regards to both time and money.

Unfortunately, educational assessment does not always follow the guidelines specified by the SEECC Model. Often no initial screening is undertaken before referral. Moreover it can often involve a lengthy wait before the specialist is available. This is especially true in rural or remote communities.

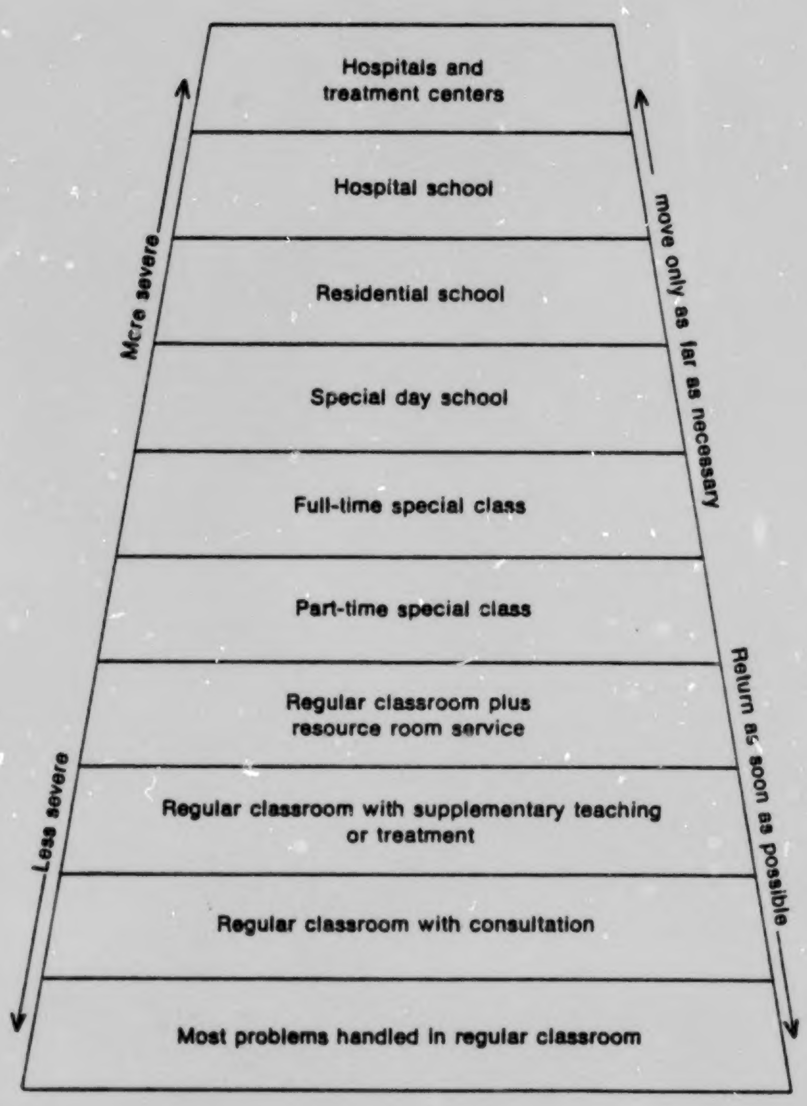

Hospitals and treatment centers
Hospital school
Residential school
Special day school
Full-time special class
Part-time special class
Regular classroom plus resource room service
Regular classroom with supplementary teaching or treatment
Regular classroom with consultation
Most problems handled in regular classroom
More severe
Less severe
move only as far as necessary
Return as soon as possible

Figure 1: Possible levels and locales at which educational assessment may take place. From (Committee on Teacher Education and Professional Standards, 1971). The gradual narrowing of the chart indicates the lesser number of children as programs become more specialized.

The main reason that assessment is not undertaken by the regular classroom teacher is lack of expertise. A teacher's practical experience may be limited to one or two cases encountered during university studies. Furthermore, tests and procedures change. Even an experienced diagnostician requires information about recent trends, procedures, materials and tests.

As more teachers are trained to assess and teach exceptional children, the initial diagnosis (with some guidance) could be carried out by the regular classroom teacher or the resource room teacher. In many cases, by providing sufficient guidance and appropriate materials, the child need not be removed from the regular school environment for diagnosis or remediation. An expert consulting system is one means of enhancing the SEECC Model (see Figure 2) in order to facilitate assessment within the regular school environment.

2.2 The Role of an Expert System

The main purpose of a computer-based diagnostic system is to assist teachers in the assessment of learning difficulties. The system guides the user through the various stages of diagnosis, from the initial screening through to a prescription. At each stage, the expert system analyzes the available data and suggests an appropriate next step. It may request information regarding the child's developmental history or academic skills. The

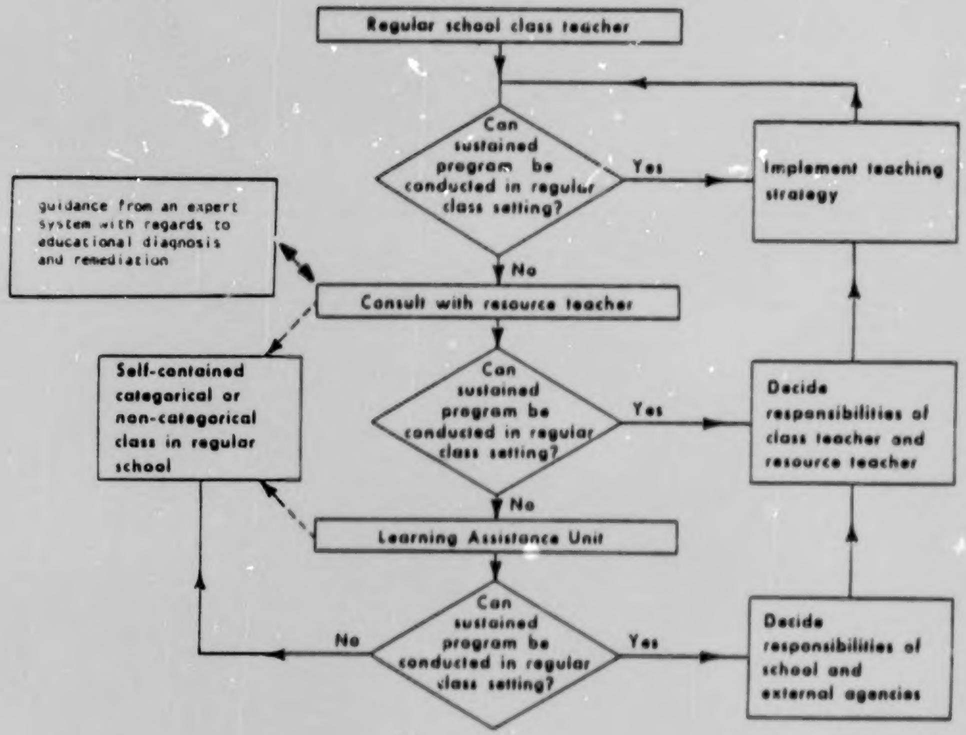

Regular school class teacher
Can sustained program be conducted in regular class setting?
Yes
Implement teaching strategy
No
guidance from an expert system with regards to educational diagnosis and remediation
Consult with resource teacher
Self-contained categorical or non-categorical class in regular school
Can sustained program be conducted in regular class setting?
Yes
Decide responsibilities of class teacher and resource teacher
No
Learning Assistance Unit
No
Can sustained program be conducted in regular class setting?
Yes
Decide responsibilities of school and external agencies

Figure 2: A model for the delivery of educational services to exceptional children. Adapted from (McLeod, Sanche & Bloom, 1979).

administration of a particular standardized test may be advised, or it might recommend further assessment of a skill or ability not within its domain of expertise. This might include consultation with a specialist or a referral to an outside agency.

The teacher or diagnostician performs the required task, such as obtaining the requested data, or administering the appropriate test, and supplies this information to the system. After this new data has been assimilated and analyzed the system proposes the next step, and so on. Eventually, the system provides a summary of its diagnostic findings along with a prescription, including appropriate remedial activities and instructional techniques.

The system does not necessarily test the student directly, nor does it manage the testing activities. Rather it guides the diagnostician. Hence, the term "computer-guided" diagnosis is employed.

Interaction is between the computer and the diagnostician, with the system posing questions or making appropriate suggestions. When the desired information is not available, the system must give the user the option of breaking contact in order to obtain the necessary data. In the case when the system must have further input in order to continue the diagnosis, the system reiterates what information is required and then terminates the session. In some cases, it may be impossible to obtain all of the desired information; hence, the system must be able to handle incomplete data. Moreover it should be able to detect erroneous information, as not all test administrations are valid.

When a teacher initiates a diagnostic session, the system will first ask if instructions are required. If so, the user's manual, including a description of the system, its use and the underlying model of educational diagnosis will be provided. Secondly the system must ascertain if a new case is being presented. If so, the appropriate biographical information (child's name, birthdate, sex, parents' names, address, etc.) must be provided. Assessment is then initiated. Alternatively, the system accesses the child's file which contains all the data accumulated to date, and assessment continues.

Throughout the diagnostic procedure, the system is to guide the user. It may suggest appropriate tests but the final control is the teacher's. In order to facilitate decision-making, the system provides the following information for several proposed tests: test name, age range, available levels and forms, appropriate subtests and approximate administration time. Additional information which the user could request includes the publisher, date of publication, summary of norming information, and the type of information the test provides. Furthermore the system may recommend a particular form or level, depending upon the child's age and previous testing. However the user must choose the most appropriate test; the teacher's level of expertise and the availablility of the test materials are both determining factors.

The interaction considered so far has only been between the computer and the diagnostician. Interaction between the computer and the child could also be incorporated. In fact, administration of many standardized tests has been computerized.

One of the first tests to be scored and interpreted by a computer program was the Minnesota Multiphasic Personality Inventories (MMPI) (Pearson, Swenson, Rome, Mataya & Brannick, 1965). The MMPI is well-suited to computerization because of its objective scoring and its numerically-based interpretations. Other tests which have been fairly straightforward to adapt to computerized scoring and interpretation include the Sixteen PF Questionnaire (Nichols & Knopf, 1977), the Clinical Analysis Questionnaire (Nichols & Knopf, 1977), the Briggs Social History (Johnson & Williams, 1978), the Deck Depression Inventory (Johnson & Williams, 1978), the California Psychological Inventory (Scissons 1976), and the Eysenck Personality Inventory (Katz & Dalby, 1981).

One area of psychological testing which has received recent attention is the automation of intelligence tests. The Slossen Intelligence Test (Hedl 1971), the Raven's Progressive Matrices (Knights, Richardson & McNarry, 1973), and the Peabody Picture Vocabulary Test (Klinge & Rodziewica, 1976; Overton & Scott, 1972) have all been adapted for administration, scoring, and interpretation by various computer systems.

However, the intelligence tests most commonly employed for individual assessments are the Revised Wechsler Intelligence Scale for Children (WISC-R), the Stanford-Binet Intelligence Scale (Stanford-Binet), the McCarthy Scales of Children's Abilities (McCarthy), and the Illinois Test of Psycholinguistic Abilities (ITPA). Because the WISC-R is the most commonly administered individual intelligence test, it has attracted the most attention. Rakiecki, Quackenbush, and Hynd (1978) developed a computer program to convert WISC-R raw scores into scaled scores, intelligence quotients and percentiles. The program also produces a profile of the individual's strengths and weaknesses. This is all fairly straightforward. The program does, however, include an indication of both psychological and learning weaknesses and methods of remediation. Other researchers have considered automated or computerized administration of the Wechsler Intelligence Scales (Elwood, 1972; Hunka, 1973). With regard to the automation of other intelligence tests, little has been done. Analysis of the ITPA subtest scores, as specified in the test manual, is straightforward and easily programmed. The author is unaware of any attempt to computerize the administration of the ITPA, the McCarthy or the Stanford-Binet.

When a standardized test is computerized, it must be renormed, because testing conditions have changed.

Furthermore, not all computerized testing environments are conducive to eliciting a child's maximum performance -- an assumption of many standardized tests. In the event that the test administration has been computerized and normed accordingly, testing can take place at the computer terminal. In such cases, the scoring and interpretation of the results is handled directly by the system.

Computerized testing need not be restricted to standardized tests. Progressing through the various stages of diagnosis, the child's skills are subject to closer and closer scrutiny. Standardized tests are often inappropriate during the later stages of assessment. Ideally, tasks are tailored to the child's abilities in order to pinpoint difficulties. At this stage the computer can be employed to generate appropriate criterion-referenced test materials. The system could either interact directly with the child, or provide the teacher with a copy of the test (including all necessary instructions and materials) for administration.

Many of the available CAI packages include testing, some of which are suitable for adaptation to a diagnostic expert system. Software which could ultimately be incorporated includes computerized testing of specific reading, spelling and arithmetic skills.

In the case of arithmetic, there is general agreement regarding the difficulty of various operations and the necessary subskills. Hence, effective heuristic methods exist for generating appropriate tests in order to assess a child's arithmetic skills. It is often harder to ascertain the child's difficulties when errors arise from a faulty algorithm. Recent research has included simulating children's arithmetic errors in order to pinpoint algorithmic problems (Brown & Burton 1978; Burton, 1981; O'Shea & Young 1978). A student's errors are viewed as symptoms of an algorithmic 'bug' -- a modification in the true procedure. Bugs may result from deleting part of the correct procedure, adding an incorrect subprocedure, and so on. A system to detect such errors in subtraction problems is operational (Burton, 1981). Children need not interact with the system directly; for example, the teacher could supply the child's answers for the system to analyze. Either format is a possibility.

There are several relevant projects regarding computer-assisted testing of reading skills. Knights and Hardy (1976, 1977, 1978) have developed a program to assist teachers in diagnosing reading problems. They have developed tests for five basic reading skills: grapheme-phoneme production, sight word recognition, visual segmentation, word attack and auditory blending. These are subsequently broken into smaller, progressive units or subskills. The teacher and the child interact with the computer, supplying the child's response to each item. At the end of the testing, the system prints a profile of the child's strengths and weaknesses, along with a suggested outline for remediation.

Another project, undertaken at the University of Wisconsin, examined the feasibility of using PLATO for examining a child's reading skills (Venezky, Bernard, Chicone & Leslie, 1975; Venezky, Chicone & Perry, 1976; Venezky, Perry, Chicone & Pittelman, 1977; Johnson, Pittelman, Schwenker & Perry, 1978). The areas of reading investigated by these researchers include letter-sound encoding, comprehension and vocabulary. The PLATO system is designed for direct interaction between the child and the system.

There is no reason that computer-based reading tasks must be limited to the areas or skills mentioned above. Many informal reading tests can easily be computerized.

Similarly, informal spelling tests can be incorporated with the child's errors classified according to a previously specified scheme. It is generally straightforward to have the computer administer a spelling test. However, a child's responses may be different depending whether he/she is asked to write or type the word. Before adapting tests requiring written responses, it must be determined that such modifications are valid. An alternative approach would be for the teacher to enter the child's responses, or employ graphic input devices capable of analyzing normal handwritten responses. Yet another choice is for the child to select the correct spelling from several alternatives. Again, the validity of these tests may be less than those requiring written responses.

Whatever the area of assessment, the system must ultimately provide the user with a summary of the diagnostic findings and recommendations for remediation. The latter should include appropriate activities and instructional techniques, as well as suggestions regarding who should participate and where. The recommended activities may be commercial materials or computer-generated activities tailor-made for the child. These could be designed with consideration of the child's strengths, weaknesses, age and interests. Some of the prescriptive teaching can even be undertaken in a CAI format.

The database of activities should be continually updated. An appropriate computer program can be developed to analyze the accumulated data from each diagnosis and remediation. This analysis should be augmented by teachers' evaluations of the various instructional techniques and materials, as well as their recommendations of others. In this way, unsuccessful activities are progressively eliminated.

CHAPTER THREE

THE DESIGN

3.1 Introduction

It is not the aim of this thesis to develop the entire expert consulting system outlined in Chapter 2. Rather, it is to demonstrate the feasibility of such a system, i.e. that a series of computer programs can be developed and implemented to guide the user through the various stages of educational diagnosis. It is our hypothesis that an expert consulting system can provide the necessary guidance. Furthermore, the information contained in the resulting diagnostic report will be comparable with that normally provided by human diagnosticians.

3.2 McLeod Educational Diagnostic Model

There is no single correct approach to educational diagnosis, although there are commonsense guidelines and recommended procedures. All diagnoses should be logical and systematic, culminating in recommendations regarding the most appropriate educational environment, and a description of remedial activities appropriate for the child's current level of skills and abilities.

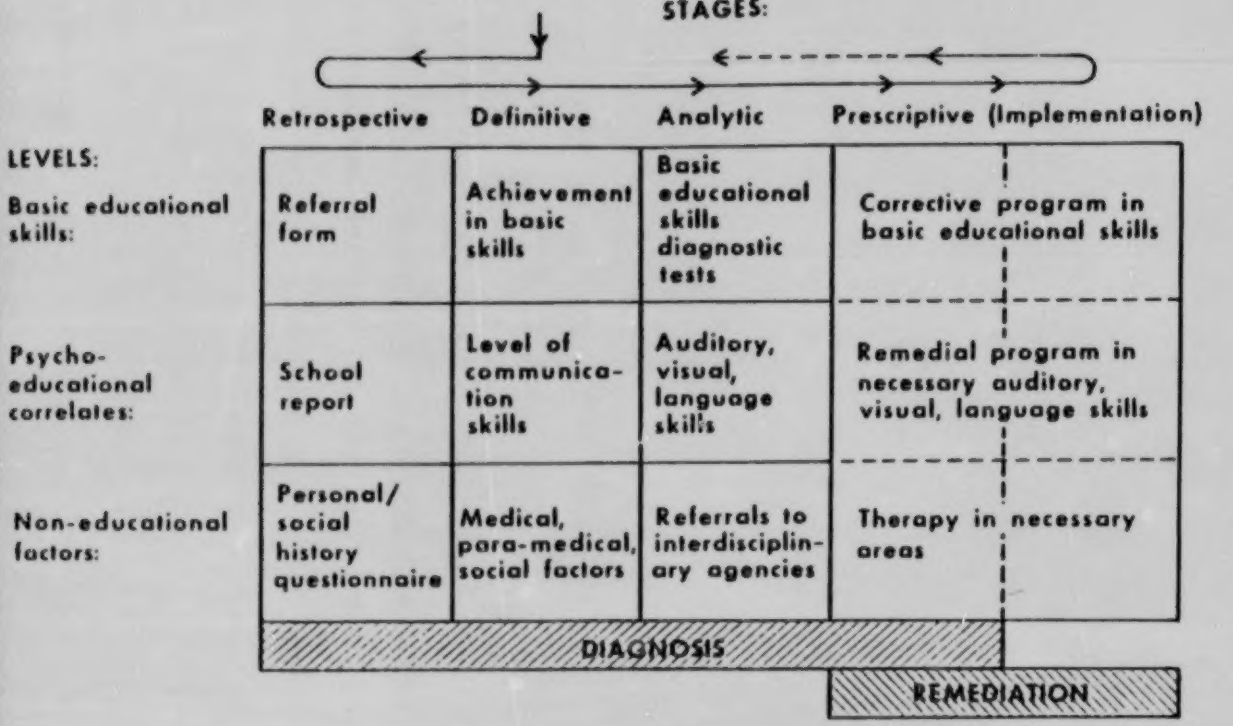
The literature on educational difficulties contains many suggestions regarding diagnostic procedures (Bond & Tinker, 1973; Salvia & Ysseldyke, 1978; Wallace & Larsen, 1979). Educational diagnosis is more than an examination of the child's academic abilities. All contributing factors must be examined. For this reason, most diagnosticians commence by gathering data regarding the child's developmental history including intellectual, emotional, physical and academic development. It is important to collect only pertinent information and to do so as efficiently as possible; assessment is costly. It is generally accepted that standardized tests should be employed as much as possible in diagnosis, using informal assessment as required. Furthermore, a diagnostic decision should never be based upon a single score; all relevant information must be considered. A comparison to the child's chronological peers, and a determination of relative strengths and weaknesses are both necessary.

These principles are fairly consistent across all models of educational diagnosis. However, in themselves, they do not constitute a model of diagnostic procedure. The literature does contain several such models (Bateman, 1965; Chandler & Siegel, 1982; Lerner, 1976; McLeod, 1982; Otto & Smith, 1980; Wallace & Larsen, 1979). Our frame of reference is chosen to be the model which most reflects the diagnostic procedures practiced in Saskatchewan. The selected model, the McLeod Educational Diagnostic Model (McLeod, 1976, 1982), has the additional advantage of being a generally accepted frame of reference which represents a logical, systematic approach to diagnosis. Furthermore, it incorporates the aforementioned principles of diagnosis.

The model consists of four stages: Retrospective, Definitive, Analytic and Prescriptive. Within each stage, there are three levels: basic educational skills, psychoeducational skills and non-educational factors (see Figure 3). Each of the twelve components represents a different aspect of assessment. Hence, different data is gathered within each segment. Although the model specifies what type of information is to be collected, it does not designate which tests are to be administered. This is to be determined by the diagnostician.

This flexibility is one of the model's appealing features. For an expert system to be adaptable, flexibility is essential. Experts do not always agree as to which information is relevant or which tests should be administered. Hence, for a diagnostic system to be valuable over time and across various experts' domains, it must be flexible. Initially, the information employed by the system may be based upon the knowledge of one expert. However, other experts' knowledge and opinions can be incorporated later, if the initial system design is flexible.

Diagnosis begins with a suspicion that the child is experiencing learning difficulties and progresses through to an appropriate prescription. However, it does not terminate at this point. It should be a continual process, with constant assessment of the child's progress during the Prescriptive stage. The fundamental stages of a diagnosis are as follows:



LEVELS:	Retrospective	Definitive	Analytic	Prescriptive (Implementation)
Basic educational skills:	Referral form	Achievement in basic skills	Basic educational skills diagnostic tests	Corrective program in basic educational skills
Psycho-educational correlates:	School report	Level of communication skills	Auditory, visual, language skills	Remedial program in necessary auditory, visual, language skills
Non-educational factors:	Personal/social history questionnaire	Medical, para-medical, social factors	Referrals to interdisciplinary agencies	Therapy in necessary areas

Figure 3: The McLeod Educational Diagnostic Model. From (McLeod, 1982).

(1) Retrospective	relevant data about the child's previous developmental history is reviewed;
(2) Definitive	the existence -- or non-existence -- of a learning disability is established;
(3) Analytic	surface symptoms are subjected to progressively finer scrutiny;
(4) Prescriptive	corrective or remedial action is initiated.

The Prescriptive stage is both the final stage of the initial diagnosis and the first stage of remediation. The model also specifies three levels of information:

- basic educational skills in areas such as reading, spelling and arithmetic;
- psycho-educational correlates which include those intellectual, visual, auditory and language skill deficiencies which might be related to learning disabilities;
- non-educational factors which are primarily in the medical, social and developmental sectors.

Boundaries between these levels and stages are not well defined. For example, the child's emotional status may be considered at either the psycho-educational level or as a non-educational factor. It is important that such information is incorporated; the level at which to do so is dictated by personal preference.

It is exactly this type of decision which must be made during the initial design of our expert system. The type of information to be collected within each component of the model must be determined. Although these decisions are essential, they will not be readily apparent to the user.

Diagnosis usually begins with a referral which indicates the child's general areas of difficulty. Further information regarding the child's developmental history is then obtained from school and parents. The former supplies information regarding the child's academic skills, motor skills, behaviour and emotional development. Data concerning the family situation, the child's medical history, language development, motor skills, behaviour and emotional development is collected from the parents. This can comprise a large amount of data, hence the present study has concentrated on collecting information which has been shown to be educationally or clinically significant.

The Definitive stage is the first direct diagnostic involvement with the child. At this stage, the child's intellectual abilities and general achievement in reading, spelling and arithmetic are assessed. For each subject area, it must be determined whether the child's skills warrant further assessment. If this is the case, the abilities are analyzed further. For example, if the child's general achievement in arithmetic is poor, diagnosis proceeds by determining which general areas of mathematics are presenting difficulties. It is also at the Definitive stage that a language screening test is administered or further assessment is recommended for medical, emotional or behavioural problems, if necessary.

At the Analytic stage, the child's skills and abilities are analyzed further in order to pinpoint problems. Simultaneously, the diagnostician must establish which skills are already mastered so that appropriate remedial instruction can be proposed. For example, if a child is experiencing reading difficulties, the level of the child's phonic skills must be ascertained. Are the child's phonic skills adequate? If not, does he/she have difficulty with initial consonants? If so, which ones? This amount of detail is necessary if appropriate remedial instruction is to be planned.

The child's language skills should also be subjected to the same scrutiny as the academic subjects. Also, within the second level of the Analytic stage, it might be necessary to examine the child's visual and auditory perception, and fine and gross motor skills.

The adaptation of the McLeod Educational Diagnostic Model employed here terminates after the second level of the Analytic stage. Medical and behavioural problems are not of further concern, as the necessary referrals were suggested at the Definitive stage. Nor are the diagnostic findings translated into remedial activities.

There are several reasons for eliminating the Prescriptive stage. Although it is a crucial aspect of diagnosis, it is not essential to this project. The feasibility of computer-guided diagnosis can be established by producing a diagnostic report which outlines the child's difficulties. The diagnostician can then employ this output to prescribe remedial or corrective instruction.

Secondly, few experts agree upon appropriate remedial materials. There is better consensus as to what should be specified upon completion of the Analytic stage. Hence, it seems appropriate to terminate here and let experts judge the system while personal preference is less apt to distort their perception of the system's performance.

Furthermore, it is a major task to decide which remedial activities and instructional techniques are most appropriate for the child in question. There are thousands of educational commercial products on the market. To judge these adequately would be far beyond the scope of a magisterial thesis. Therefore, it was decided not to include the Prescriptive stage. Rather, the diagnostic model is restricted to all three levels of both the Retrospective and Definitive stages and the first two levels of the Analytic stage.

3.3 The Intended User

Any computer system must be designed with the user in mind. In this study, the user's level of expertise with respect to both the general use of computers and educational diagnostic procedures must be taken into account. The expert system that has been developed is intended for teachers of either regular classrooms or resource rooms. No previous experience with computers is required. However, the user must be familiar with standard diagnostic procedures. In fact, the system is intended for teachers who have at least a full university course concerning theoretical and practical issues of diagnosing learning disabilities. At the University of Saskatchewan, the appropriate half-courses are Edexc 448 and 449 (previously, the full course Edexc 450).

Students successfully completing these courses are considered to have an adequate understanding of the following topics or issues:

- aims of psycho-educational diagnosis
- complementary relationship between diagnosis and prescriptive instruction
- approaches to principles of diagnosis
- concepts and terminology of testing and diagnosis
- current issues in research and legislation
- SEECC model
- McLeod Educational Diagnostic Model
- administration, scoring and interpretation of standardized tests.

Furthermore, Edexc 448 is a practical course where students assess a child's learning difficulties, commencing with the referral from the school and terminating with recommended remedial activities.

Although the expert system will guide the user through the stages of diagnosis, the teacher must still administer and score the appropriate tests. Therefore, the user must be familiar with the principles of testing and assessment. Consequently it is recommended that the user have the level of expertise obtainable through a full year course on psycho-educational diagnosis.

3.4 Selection of Subject Area and Age Range

The assessment of learning difficulties is an enormous topic; consequently a feasibility study must be restricted to a more manageable size in view of the time, funding and personnel constraints. Therefore, the project has been limited to aiding teachers in the diagnosis of reading difficulties, in part because reading difficulties represent the main reason for referrals to the Institute of Child Guidance and Development. A second restriction is to the assessment of children ages eight through ten inclusive. Although the system is by no means inappropriate outside of this age range, its users should bear this in mind.

3.5 System Components

The model of diagnostic procedure, the intended user, and the subject area having been determined, the system design can be specified. Most expert systems are *production systems* (Davis & King, 1976; Nilsson, 1980; Young, 1979), consisting of three components:

- a *global database*
- a *set of production rules*
- a *control structure*.

In our system, the global database serves as the child's file. It contains all relevant information pertaining to the particular child being assessed. For example, the global database contains information from the School Report and the Parent Questionnaire. For each administered standardized test, the global database contains the aggregate test score, subtest scores, date of administration and any other information normally associated with the test.

The production rules represent the experts' knowledge, i.e. an encoding of how the experts handle particular situations. Each rule has a precondition, which must be satisfied before the rule may be applied. All rules are of the form

"situation or condition ---> action"

The condition may be a low score on a particular test or subtest. The resulting action may mean the administration of another standardized test. For example, a possible rule is the following:

CONDITION:	ACTION:
Test: Wide Range Achievement Test Subtest: Spelling Type of Score: Spelling Quotient Score: less than 90	administer a test, such as the Test of Written Spelling (TWS) to assess the child's spelling skills.

After the TWS is administered, resulting scores will be stored in the global database. Hence, the application of a production rule results in the information in the global database being updated.

The third component of a production system is the control structure, a computer program that governs which appropriate production rule will be applied. There may be several production rules from which to choose. Hence, the control structure must have some means of making logical, efficient choices. In essence, the control structure is responsible for coordinating the entire diagnostic process.

3.5.1 The Control Structure

Within the McLeod Educational Diagnostic Model, assessment proceeds through the stages in the following order: Retrospective, Definitive, and Analytic. Within each stage, diagnosis progresses from level one to three. Hence, the expert system commences assessment at level one of the Retrospective stage, which involves accessing the production rules associated with this component of the educational model. The appropriate system file is incorporated, allowing the control structure to examine the component's production rules.

Within each component of the diagnostic model, the control structure performs the same tasks. The control structure examines each production rule in turn, determining whether it is applicable. Several of the component's rules may be appropriate; from these, the control structure selects the best. The rule is then executed, i.e. the action specified by the rule is performed. The execution of a production rule always involves updating the global database. As a result, a rule previously considered applicable may be inappropriate, or vice versa. Hence, the control structure must re-examine all of the component's production rules to determine which ones are now suitable. This cycle of examination, selection and execution continues until no rule is applicable.

At this point, the control structure determines which component to enter next. For example, from the Retrospective Stage Level 1, assessment proceeds to Level 2 of the same stage. The production rules for this component are then accessed from the appropriate system file. The control structure again examines each in turn, selects one and executes it. As before, this process is repeated until no rule is appropriate for execution. In this manner the control structure determines the system's progress through the various stages and levels of the diagnostic model, as well as controlling the execution of the system's production rules within each component.

Each production rule specifies a set of conditions which must be satisfied before the rule is executed. The control structure examines these conditions in order to determine whether a rule is applicable. A second module of each production rule specifies the action to be undertaken when the rule is executed. By convention, the preconditions are said to constitute the rule's left-hand side (LHS); the action, the right-hand side (RHS).

In order to examine a rule's specified preconditions, the control structure executes the rule's LHS. When the LHS of a production rule is executed, a quantitatively defined priority is associated with the rule (if the necessary preconditions are satisfied). After each rule in the component is examined, the production rule of highest priority (which is the rule with the smallest associated numerical value) is selected. The RHS of the selected rule is then executed. Although the LHS of a rule may access various data structures in the global database, it does not change them. On the other hand, the execution of the RHS of a rule will always update the global database.

Although the system proceeds through each stage and level of the diagnostic model, this does not mean that production rules within each component must be executed. In some cases, no rule within a particular component may be applicable. Consider the case where the child's achievement in all academic subjects is better than average. No further assessment of these subjects is necessary. As a reflection of this, no further rule at the academic level (e.g. level one) of the model is appropriate.

When the system has completed the assessment, a diagnostic report of the system's findings is available. Diagnostic reports usually incorporate recommendations regarding areas of further assessment, and suitable remedial materials and activities, but as mentioned earlier, prescriptive suggestions are not included in the system's present diagnostic reports.

Not only does the control structure determine the execution of the production rules, it acts as the interface between the user and the computer programs. In Chapter 2, various features which should be incorporated into the interface were mentioned.

Expert systems which have been designed for general use, such as INTERNIST (Pople, 1975, 1977), include appropriate interfaces. Few users are experienced in the operation of computers and the interfaces have been developed with this in mind. The appealing features of the interfaces are independent of the expert system or its application. Because other research has already demonstrated that an appropriate interface can be developed, this important system module has been ignored in the present feasibility study. Furthermore, it is not necessary at this stage of development. The test cases employed in the present study are not diagnoses in progress; they are diagnoses where all the appropriate information is already available. Hence, there is never a need to terminate execution prematurely in order to administer a particular test. No information will ever be marked 'PENDING'. Consequently, an elaborate interface is not required.

By restricting the interface to essentials, several implicit assumptions have been made. For example, the system will presume that all entered information is correct. Hence, it contains no general means of checking whether a test administration may be invalid. Such features must ultimately be included but are not fundamental in a feasibility study.

3.5.2 The Production Rules

Production rules constitute the second major component of an expert system. For each implemented component of the McLeod Educational Diagnostic Model, a description of the production rules is contained in Chapter 4. The rules, encoded in the programming language LISP, are in Appendix D.

The development of the rules was, in itself, a major undertaking. For each component of the model, one must ascertain

- what data is normally collected
- the usual sources, e.g. questionnaires, test, previous assessments
- how this information is applied, e.g. what facts, suspicions, hunches are concluded when this new knowledge is assimilated.

To establish this information, the following sources were consulted:

- previous Edexc 450 diagnoses
- local psycho-educational experts
- research literature.

Previous diagnoses undertaken by Edexc 450 students throughout the 1971-1973 period provided the primary source. Files pertaining to children between the ages of eight and ten who had been experiencing reading difficulties were examined in detail. At each stage of diagnosis, notes were made on the information gathered, including the tests administered, their results and the diagnostician's conclusions. Assessing the latter incorporated an examination of the diagnostic report to determine whether further assessment had been deemed necessary. If not, were the child's skills considered average or better? If further diagnosis was recommended, was the child referred elsewhere? As diagnosis continues, the child's skills are subjected to closer scrutiny, i.e. subskills are analyzed. It is necessary to determine which of the many subskills the diagnostician chose to assess further and why.

After analyzing approximately 50 files, the author prepared a preliminary draft of the production rules. It is impossible to ascertain all factors contributing to a diagnostic decision, and thus production rules are an approximation to the actual decision procedures. This is particularly true of the criteria for further assessment. For example, if the child's score on the Schonell Word Recognition Test represents a reading quotient of 95, is further assessment warranted? What if it is 90? Often the test manuals contain appropriate guidelines. When this is not the case, the criteria have to be estimated by experience and cumulative fine tuning.

Because the production rules are based on previous diagnoses, they necessarily reflect some of the preferences of the time, including test selection. In addition to the more general production rules, rules were developed for:

Illinois Test of Psycholinguistic Abilities (ITPA)
Neale Analysis of Reading Ability (Neale)
Gates-McKillop Reading Diagnostic Tests (Gates-McKillop)
Domain Diagnostic Phonic Tests (Domain)
Wepman Auditory Discrimination Test (Wepman)

In addition, criteria for further assessment were established for the Revised Wechsler Intelligence Scale for Children (WISC-R), the Schonell Word Recognition Test, and the Schonell Graded Word Spelling Test.

3.5.3 The Global Database

The third component of a production system is the global database, which is a collection of data structures. During the design stage, no commitment was made to particular data structures, as data structuring capability varies widely with the choice of programming language. The actual data structures and other implementation details are discussed in the next chapter.

CHAPTER FOUR

THE IMPLEMENTATION

4.1 Selection of Programming Language and Computer System

The first step in implementation is the selection of the programming language and computer system. It was decided to implement the expert system in the programming language LISP (Meehan, 1979) on the DEC 2060. LISP is an interactive language which lends itself particularly well to production systems. Its interactive nature and its built-in editor are two appealing features when implementing large programming projects such as the present. Furthermore, LISP does not differentiate between program and data. Consequently, LISP functions can be stored in the global database and treated as data. This is an appealing concept which proves useful in incorporating a user interface.

The selection of LISP as the programming language determines the type of data structures employed throughout the expert system. All data structures are property lists. For example, biographical data is stored in the data structure CHILD under the associated properties FIRST-NAME, BIRTH-DATE, AGE and SEX. Values can be assigned to each of the properties; for example, the data structure CHILD may have the following values associated with its properties:

CHILD	
FIRST-NAME	Bill
BIRTH-DATE	(21 2 1962)
AGE	(13 2 26)
SEX	M

LISP expects values assigned to a data structure's properties to be of a prescribed format (i.e. lists or atoms). As a result, the user is occasionally required to enter data in a particular format, such as a list. The existence of the system's interface could remove these requirements, as it could reformat the user's input to satisfy LISP specifications.

4.2 Implementation of System Components

The control structure, because it is completely independent of the production rules, was implemented and tested separately. Then followed the task of transcribing all of the production rules into LISP. Each diagnostic component was initially tested and debugged in isolation, followed by further testing on the entire system. It is at this stage that developers generally discover that their expert system bears little resemblance to the performance of a human expert. The system must be honed.

Eighteen of the Edexc 450 files, used during the design phase, were selected as a basis for system testing. Where the system failed to produce the same behaviour as the human diagnostician, adjustments were made. Such modifications largely consisted of altering the criteria for further assessment. For example, should further assessment be recommended if the child's score on a general achievement test is 1 standard deviation below the mean or 0.7 standard deviations below the mean? Of course, it varies from test to test. For example, children tend to achieve higher standardized scores on the Reading Recognition subtest of the Peabody Individual Achievement Test (PIAT) than on the Schonell Word Recognition Test. Such facts must be taken into account. Hence, many of these boundary values were modified and improved through experience during this fine-tuning stage.

4.3 Using the System

The system is currently available in developmental format, although it is not intended for general use. Instructions have been provided regarding its use in order to illustrate the interaction. After the necessary initialization (invoking LISP and loading system files), interactive communication begins. The system poses one question at a time and waits for the user to supply the answer. The user has the option of responding 'DK' (don't know). An affirmative answer is any one of 'YES', 'Y', 'TRUE' or 'T', and a negative answer is any one of 'NO', 'N', 'FALSE' and 'NIL'.

When the user is asked to enter a date, the system is expecting numerals, and will provide a prompt for the year, the month and the day. Similarly, if an age-equivalent is being requested, the system provides separate prompts for both the years and the months. The system automatically converts an age equivalent score to a quotient and stores both in the appropriate data structure.

Each time the user administers a standardized test, the system asks for:

- the abbreviated test name (a response of 'N' indicates that an appropriate test was not administered)
- the date of administration
- the type of test score
- the child's score

If the user's response must be in a special format (e.g. a list), this is specified in the system's question. For example, when requesting which school grades have been attended and repeated, the system specifies format and special responses:

- Enter the grades which the child has attended, as a list of numerals e.g. (K 1 2 3 4). Enter N if the question is not appropriate. Enter DK if the information is not available.

- Enter the grades which the child has repeated, as a list of numerals e.g. (1). Enter (0) if no grades have been repeated. N=question is not appropriate, DK=information not available.

To facilitate accuracy and efficiency, it is wise to have the relevant information available in manual note form beforehand. This is particularly true for the Retrospective stage of the model. It may be necessary to examine several responses on the School Report or Parent Questionnaire in order to respond to a single question of the system. For example, one system item is "Fine motor skills: Enter the general rating computed from the School Report". Before responding, the diagnostician should examine the ratings provided on the School Report which are relevant to fine motor skill in comparison with chronological peers, e.g.

using scissors, forming letters and numerals, drawing and rapid finger movements. These should be averaged to obtain a numerical rating. For instructions on computing such ratings from the School Report and Parent Questionnaire, see Appendix E.

In all other components of the diagnostic model, the information requested by the system can be obtained directly from the various test forms, although for tests such as the Neale, some analysis of the data beforehand is advisable.

To illustrate the capabilities of the system, a sample interaction between the user and the system is included in Appendix B.

4.4 System Output

As a general rule, all information of interest is presented in the diagnostic report. The global database, however, contains all of the entered data as well as resultant computations. Although it is too voluminous for efficient use in the immediate teaching situation, it is a vital component of the system. Any future extensions or modifications as a result of subsequent feedback, would be built upon the information stored in the global database. Appendix B contains a complete example of the global database.

Of far more importance to most users than the global database is the diagnostic report. This is a summary of the system's findings throughout the diagnosis. Where much information has been derived from a particular test administration, this is indicated. The report also includes a list of "further assessment flags" (FA) and descriptors. The former indicate areas in which the child's skills should receive further analysis. The potential flags are as follows:

FLAG:	AREA REQUIRING FURTHER ASSESSMENT:
FA-INTELLECT	intellectual ability
FA-BEHAV-EMOT	behaviour or emotional problems
FA-HEARING	hearing
FA-VISION	eyesight
FA-VIS-PERCEPTION	visual perception including the ability to discriminate visual symbols
FA-AUD-PERCEPTION	auditory perception including the ability to differentiate between similar sounds
FA-MOTOR-GROSS	gross motor skills
FA-MOTOR-FINE	fine motor skills
FA-SPELLING	spelling skills
FA-ARITHMETIC	arithmetic skills
FA-LANGUAGE	ability to communicate through oral and written language
FA-WRITING	handwriting skills
FA-COMPREHENSION	reading comprehension
FA-DECODING	ability to decode unfamiliar words
FA-LETTERS	knowledge of letter names and sounds
FA-SOUND-BLENDING	ability to blend sounds together

The descriptors provide a precise presentation of the system's diagnostic findings. As such, they are the basis upon which remedial activities will be prescribed. Furthermore, they provide a means of comparison with the diagnostic reports prepared by human diagnosticians.

The descriptors are classified as either strengths, weaknesses, average abilities, relative strengths, relative weaknesses or relative average abilities. A skill is categorized as a strength when, compared to the child's chronological peers, the child's ability is better than average. For example, a Full Scale Intelligence Quotient of 120 on the WISC-R would indicate that intellectual ability is a strength. A relative strength, on the other hand, involves a comparison to the child's other abilities. If the mean of the child's subtest scaled scores on the ITPA is 29, a score of 36 on the Sound Blending subtest indicates a relative strength, even though it is average for the population as a whole. It is important when planning remedial and corrective instruction to consider relative strengths and weaknesses as well as absolute strengths and weaknesses. Therefore, the expert system categorizes the descriptors accordingly.

Not all descriptors are appropriate for all categories. For example, the ITPA manual suggests that the child's overall performance for each channel, process or level should only be examined relative to his/her other skills. From the child's errors on the Neale, the system determines whether the child is making a high proportion of word reversals. In so doing, the system compares the number of reversals to the child's total number of errors; the resultant descriptor is classified as a relative weakness.

A complete list of descriptors, interpretations and appropriate categories follows. The category abbreviations are:

S = strength
W = weakness
RS = relative strength
RW = relative weakness

A = average ability   RA = relative average ability

DESCRIPTOR	INTERPRETATION	CATEGORIES
Ability		
auditory-reception:	ability to derive meaning from verbally presented material	S W A RS RW RA
visual-reception:	ability to derive meaning from visually presented material	S W A RS RW RA
auditory-association:	ability to relate concepts presented orally	S W A RS RW RA
visual-association:	ability to relate concepts presented visually	S W A RS RW RA
verbal-expression:	ability to express ideas vocally	S W A RS RW RA
manual-expression:	ability to express ideas manually	S W A RS RW RA
grammatical-closure:	ability to make use of redundancies in oral language in acquiring habits for handling syntax and grammatic inflections	S W A RS RW RA
visual-closure:	ability to identify a common object from an incomplete visual presentation	S W A RS RW RA
auditory-sequential-memory:	ability to reproduce digits from memory	S W A RS RW RA
visual-sequential-memory:	ability to reproduce non-meaningful figures from memory	S W A RS RW RA
auditory-closure:	ability to fill in missing parts which were deleted in auditory presentation and make a complete word	S W A RS RW RA
sound-blending:	ability to blend the separate parts of a word together to produce an integrated whole	S W A RS RW RA
auditory-channel:	ability to process information through the auditory-vocal channel	RS RW RA
visual-channel:	ability to process information through the visual-motor channel	RS RW RA
receptive-process:	ability to comprehend visual and auditory symbols	RS RW RA
associative-process:	ability to relate, organize and manipulate visual and auditory symbols in a meaningful way	RS RW RA
expressive-process:	ability to use verbal and manual symbols to transmit an idea	RS RW RA
representational-level:	ability to utilize symbols which carry the meaning of an	RS RW RA

	object	
automatic-level:	ability to perform automatic, nonsymbolic tasks	RS RW RA
auditory-discrimination:	ability to discriminate between similar sounds	W A

Achievement

reading:	general achievement in reading	S A^+
arithmetic:	general achievement in arithmetic	S A^+
spelling:	general achievement in spelling	S A^+

Reading Analysis

comprehension:	ability to understand what has been read	S W A RS RW RA
decoding-in-context:	ability to decode successfully when reading within context	S W A
context:	heavy reliance on context clues rather than decoding words	RW
beginning-substitutions:	tendency to make substitution errors at the beginning of words	RW
middle-substitutions:	tendency to make substitution errors in the middle of words	RW
ending-substitutions:	tendency to make substitution errors at the end of words	RW
reversals:	tendency to reverse words, e.g. 'saw' for 'was'	RW
naming-capital-letters:	ability to name capital letters	W
naming-lowercase-letters:	ability to name lowercase letters	W
capital-letter-sounds:	knowledge of sounds associated with capital letters	W
lowercase-letter-sounds:	knowledge of sounds associated with lowercase letters	W
initial-consonants:	ability to decode single consonants at the beginning of words	W A RW
final-consonants:	ability to decode single consonants at the end of words	W A RW
initial-consonant-blends:	ability to decode initial consonant blends	W A RW
final-consonant-blends:	ability to decode final consonant blends	W A RW
short-vowels:	ability to decode short vowels in the middle of words	W A RW
long-vowels:	ability to decode long vowels	W A RW
vowel-blends:	ability to decode vowel blends	W A RW
initial-consonants->consonant-blends:	tendency to substitute consonant blends for initial single consonants	RW

final-consonants-> consonant-blends:	tendency to substitute consonant blends for final single consonants	RW
initial-consonant-blends-> consonants:	tendency to substitute single consonants for initial consonant blends	RW
final-consonant-blends-> consonants:	tendency to substitute single consonants for final consonant blends	RW
short-vowels->long:	tendency to substitute long vowels for short vowels	RW
short-vowels-> vowel-blends:	tendency to substitute vowel blends for short vowels	RW
long-vowels->short:	tendency to substitute short vowels for long vowels	RW
long-vowels-> vowel-blends:	tendency to substitute vowel blends for long vowels	RW
vowel-blends->short:	tendency to substitute short vowels for vowel blends	RW
vowel-blends->long:	tendency to substitute long vowels for vowel blends	RW

+: There is no need to classify the achievement descriptors as weaknesses, because below average achievement is already indicated by the further assessment flags. Furthermore, more detailed descriptors are included for the area of reading and will ultimately be provided for spelling and arithmetic.

The above table lists all descriptors currently employed by the expert system in the diagnosis of reading problems. Additional descriptors can be included as other areas of assessment are incorporated into the system's domain of expertise.

4.4.1 Extensions to Arithmetic and Spelling

For example, when assessing a child's arithmetic difficulties, a general achievement test would first be administered; the appropriate descriptor, ARITHMETIC, is already employed by the expert system. If further assessment is necessary, the system currently recommends the administration of the KeyMath Diagnostic Arithmetic Test (KeyMath). A system descriptor could be employed for each subtest of the KeyMath, as is currently the case for the ITPA. This would entail a separate descriptor for each operation (ADDITION, SUBTRACTION, MULTIPLICATION, DIVISION) and each application (TIME, MONEY, MEASUREMENT) among others.

Each area or aspect of arithmetic can be analyzed further, with appropriate system descriptors developed as required. For example, a child's subtraction difficulties may reflect an inadequate knowledge of number facts or a faulty or inappropriate algorithm. The expert system's descriptors must encompass all of these problems.

If the child is employing an incorrect subtraction algorithm, the system must detect the exact nature of the misconception. System descriptors could be employed to indicate common algorithmic difficulties, including the following (Wallace & Larsen, 1979, p. 445):

- failure to borrow
- deducted from minuend when borrowing was not necessary
- increased minuend digit after borrowing
- errors due to zero in minuend
- subtracted minuend from subtrahend

Because the child may be making errors only when presented with more complex problems, the system should provide descriptors to indicate the task's level of difficulty. For example, subtraction descriptors could be used to indicate that the child is experiencing difficulties with:

- basic subtraction facts without zero
- basic subtraction facts with zero
- subtraction of ones and tens with no regrouping required
- three-digit minuend minus two-digit subtrahend, no regrouping
- two-digit minuend minus two-digit subtrahend, regrouping required

Descriptors can be developed to represent each of these levels and others, if required. A comprehensive list of sequenced arithmetic skills is contained in Hammill and Bartel (1982, p. 191).

So far, only a small subset of the necessary arithmetic descriptors has been mentioned. Ideally, the expert system would employ descriptors to represent the child's difficulties in many aspects of arithmetic, including readiness skills, fundamental mathematical concepts, the use of whole numbers, addition, subtraction, multiplication, division, fractions, measurement, etc. Each of these categories encompasses many different skills Hammill and Bartel (1982, p. 187-189); an appropriate system descriptor could be developed for each.

Descriptors can also be developed to reflect the expert system's diagnostic findings in the area of spelling. If the child's performance on a general achievement test is below average, the expert system currently recommends the administration of the Test of Written Spelling (TWS). This particular test examines the child's knowledge of both phonetically regular and irregular words. Depending upon the child's performance, the expert system would classify the corresponding descriptors, PREDICTABLE-WORDS and UNPREDICTABLE-WORDS as either strengths, weaknesses or average abilities.

If the child is unsuccessful at spelling the phonetically-regular words, further assessment of phoneme-grapheme associations would be recommended. Necessary skills which may be assessed at this stage include:

- 's' spelling of the /s/ and /z/ sounds
- 'gh' and 'ph' spellings of the /f/ sounds
- 'wh' spelling of the /g/ and /j/ sounds
- consonant sounds spelled with double letters
- silent consonants

A more complete list of skills required in representing consonant and vowel sounds can be found in Hammill and Bartel (1982), Kottmeyer and Claus (1972), Wallace and Larsen (1979). A child's difficulty with any of these essential skills would be reflected in the corresponding system descriptor being categorized as a weakness.

The system might also assess the child's use of morphemes to make structural changes when spelling. For example, does the child possess an adequate knowledge of the following:

- 's' and 'es' plurals
- changing 'y' to 'i' before 'es'
- suffixes and prefixes (and associated spelling rules)

A comprehensive list of such skills is presented in Hammill and Bartel (1982); appropriate system descriptors could be developed for each.

The expert system's descriptors must encompass all aspects of assessment. Hence, the descriptors developed for arithmetic and spelling must be comprehensive, encompassing all essential skills, not just the examples presented here. Furthermore, the descriptors should indicate common types of errors, as is currently the case with the system's analysis of the Domain.

4.5 Implementation of the McLeod Educational Diagnostic Model

The categorization of the system's descriptors (as strengths, weaknesses, etc.) is determined by the production rules. In fact, the rules represent all of the system's knowledge regarding educational diagnosis; they are the means by which the expert system models the behaviour of human experts. The actual production rules, encoded as LISP functions, are contained in Appendix D. As few readers will find the actual computer code of interest, an explanation of the rules is offered here. Before describing the system's actions within each component of the diagnostic model, a brief explanation of the system's handling of standardized tests is given.

To determine whether the child's performance is below average, average, or better, the system must determine the average range for the administered test, assumed to be the test mean plus or minus 1 standard deviation. To calculate the mean and standard deviation, the system first checks whether such information is stored in the global database under the abbreviated test name. For example, the system knows that all scaled scores on the WISC-R have a mean of 10 and a standard deviation of 3. If the information is not associated with the test name, the system then checks a general data structure, SCORE-COMPARISON, which contains the mean and standard deviation of common score types, e.g. quotients. If the desired information has still not been located, the system has the option of asking the user to supply the test mean and standard deviation.

Whenever the user supplies information to the system, it is stored in the appropriate data structures in the global database. In fact, the user's responses could be reconstructed from the data in the global database.

Before entering the first component of the McLeod Educational Diagnostic Model, the system asks the user to supply a file number. The control structure then calls in the production rules for the first component, Level 1 of the Retrospective Stage.

4.5.1 Component:	Retrospective Level 1
Purpose:	to collect relevant information regarding the child's past and present academic achievements
Information Sources:	Referral form School Report previous assessments

Because this is the first component of the McLeod Educational Diagnostic Model, it is here that the essential introductory information such as the child's name, sex, birthdate is collected. If desired, this section could be expanded to include surname, parents' names, address, phone numbers, school name, and so on. If the surname and residential information is collected, it should be encoded into a separate system file, for reasons of privacy and security.

The gathering of data regarding the child's academic development is initiated by determining the reasons for referral. For each reason indicated, the corresponding further assessment flag(s) is set to true. For example, if the child is referred because of concern over his/her motor skills and poor performance in arithmetic, the following flags would be true: FA-MOTOR-GROSS, FA-MOTOR-FINE, FA-ARITHMETIC. This will ensure assessment of these skills at the Definitive stage.

A major purpose of the Retrospective stage is to obtain an indication of the child's academic skills. This is done through teacher ratings and previous assessments.

In the School Report, the teacher is asked to compare the child to his/her chronological peers. In response to many of the questions, the teacher must provide a numerical rating: 1 (very good) through to 5 (very poor). There may be only one question pertaining to the ability in question or several. This varies from skill to skill and with the various editions of the School Report. For example, when assessing the child's fine motor skills, the teacher is asked to rate the child's ability to use scissors, to draw, to form letters and numerals, and to make rapid finger movements. The user is required to combine these responses into one numerical rating; documentation for summarizing the School Report is contained in Appendix E.

If the child's ability is worse than average (e.g. the numerical rating is greater than 3), the appropriate further assessment flag is set to true. Therefore, if the teacher's rating of the child's reading skills indicates that the child's ability is poor, the system will later assess the child's achievement in reading (whether or not reading difficulties were a reason for referral).

Finally, the system asks for pertinent information concerning any previous testing: the test name, type of test, administration date, type of test score, and the child's score. This information is not analyzed here, but within the Definitive stage.

4.5.2	Component:	Retrospective Level 2
	Purpose:	to collect information regarding psycho-educational correlates affecting the child's academic achievement.
Information Sources:		School Report

The user is asked to enter the ratings computed from the School Report for each of the following:

- gross motor skills
- fine motor skills
- spoken language
- written language
- behaviour

If the child's ability is worse than average, the appropriate further assessment flag is set to true. In addition, the user is to supply a rating of the parents' attitudes; this includes both their acceptance of the child's difficulties and their willingness to cooperate with the school. This information is generally included on the School Report, to assist the consultant in the planning of remedial activities.

4.5.3	Component:	Retrospective Level 3
	Purpose:	to collect information concerning the child's developmental history, including medical, behavioural, emotional and language development
Information Sources:		Parent Questionnaire

The system poses a series of questions in order to gather relevant information regarding the child's developmental history. The requested data can be ascertained from the Parent Questionnaire, designed to elicit information concerning the following (McLeod, 1976):

- parents' perception of the problem
- educational circumstances such as absence from school, changes of schools or teachers
- visual and auditory acuity
- developmental history
- emotional factors
- language development, particularly during the preschool years
- prenatal and perinatal factors
- neurologically-related factors such as visual-motor coordination and spatial orientation
- familial factors.

It would be too time-consuming to collect data concerning all aspects of the child's development. Therefore, only information believed to be significant is gathered.

Often several pieces of information on the Parent Questionnaire should be considered before answering the system's question. For example, the system asks whether the child's language has developed at a normal rate. An answer requires the examination of the responses to the following questions:

- At what age did he speak (apart from 'da' and 'ma')?
- At what age was his speech (i.e. two or more continuous words) intelligible to persons other than mother?
- Was his talk still immature at the age of four or five, i.e. at or just prior to starting school? (e.g. 'fink' for 'think', 'dat' for 'that'. Reference to himself by name rather that 'I' or 'me'.)
- Has he had speech therapy or speech correction?

Documentation for summarizing information from the Parent Questionnaire is contained in Appendix E.

An adverse response to a system's question causes the appropriate further assessment flag to be set to true. This guarantees further attention to this skill or factor later in the diagnostic session. As always, all information is stored in the global database's various data structures. Although not acted upon at the Retrospective stage, information concerning family difficulties, school attendance and previous medical problems is collected here, as it should be considered at the Prescriptive Stage.

The system's questions and its handling of adverse responses are as follows:

- What date was the parent questionnaire completed?

- Have the siblings experienced any school difficulties?
  Adverse Response: Yes

- Has any other family member experienced reading or spelling difficulties?
  Adverse Response: Yes

- Is the family situation favourable?
  Adverse Response: No

- Has it ever been suspected that the child has defective eyesight?
  Adverse Response: Yes

- Has the child ever been seen by an optometrist or eye specialist?
  Adverse Response: No
  System Action: If the child's eyesight was also suspect, FA-VISION is set to 'TRUE'.
  Alternate Response: Yes
  System Action:
    - What was the result? 1=normal, 2=glasses, 3=other
      Adverse Response: 1
      System Action: If the child's eyesight was suspect, FA-VIS-PERCEPTION is set to 'TRUE'.

- Has it ever been suspected that the child has defective hearing?
  Adverse Response: Yes

- Has the child ever had a hearing test?
  Adverse Response: No
  System Action: If the child's hearing is suspect, FA-HEARING is set to 'TRUE'.
  Alternate Response: Yes
  System Action:
    - What was the result? 1=normal, 2=other.
      Adverse Response: 1
      System Action: If the child's hearing was suspect FA-AUD-PERCEPTION is set to 'TRUE'.

- Have there been other medical problems which may account for the child's learning difficulties?
  Adverse Response: Yes

- Is the child nervous?
  Adverse Response: Yes
  System Action: FA-BEHAV-EMOT is set to 'TRUE'.

- Is the child over-active?
  Adverse Response: Yes
  System Action: FA-BEHAV-EMOT is set to 'TRUE'.

- Is the child moody?
  Adverse Response: Yes
  System Action: FA-BEHAV-EMOT is set to 'TRUE'.

- Has language development been normal with regards to memory?
  Adverse Response: No
  System Action: FA-LANGUAGE is set to 'TRUE'.

- Has language development been normal with regards to syntax?
  Adverse Response: No
  System Action: FA-LANGUAGE is set to 'TRUE'.

- Has the child's language developed at a normal rate?
  Adverse Response: No
  System Action: FA-LANGUAGE is set to 'TRUE'.

- Do the child's visual motor skills and visual perception appear to be normal?
  Adverse Response: No
  System Action: FA-VIS-PERCEPTION is set to 'TRUE'.

- Does the child's auditory memory and auditory perception appear to be normal?
  Adverse Response: No
  System Action: FA-AUD-PERCEPTION is set to 'TRUE'.

- Do the child's gross motor skills appear to be normal?
  Adverse Response: No
  System Action: FA-MOTOR-GROSS is set to 'TRUE'.

- Do the child's fine motor skills appear to be normal?
  Adverse Response: No
  System Action: FA-MOTOR-FINE is set to 'TRUE'.

- Does the child ever confuse left and right?
  Adverse Response: Yes
  System Action: FA-READING is set to 'TRUE'.

4.5.4 Component: Definitive Level 1

Purpose: Assessment of both the child's intellectual abilities and his/her achievement in basic skills.

Information Sources: Individual intelligence tests. Individual general achievement tests.

First the system determines if it is necessary to assess the child's intellectual ability. The previous test scores, which were provided during the Retrospective stage, are examined. If the child has obtained an average score or better on an ability test within the past two years, no further assessment is deemed necessary. Otherwise the user is asked to administer an individual test of intellectual ability. If an appropriate test is not administered, the system will comment upon this in the diagnostic report and the corresponding flag, FA-INTELLECT will be printed accordingly. This is the procedure followed whenever the user chooses not to administer a test.

Currently, specific rules have been developed only for the ITPA, because it is this ability test which appears in the majority of examined Edexc 450 files. After administering the test, the user enters the global score (PLA), and the scaled score for each administered subtest. The system then determines whether a particular subtest represents:

1. a strength, i.e. the subtest scaled score is greater than or equal to the test mean (36) plus the test standard deviation (6);
2. a weakness, i.e. the scaled score is less than or

equal to the test mean minus the test standard deviation;
3. a major strength, i.e. the scaled score is greater than or equal to the test mean plus 10;
4. a major weakness, i.e. the scaled score is less than or equal to the test mean minus 10.

These are the definitions recommended to Edexc 450 students; the latter two are consistent with those employed in the ITPA manual (Kirk, McCarthy, & Kirk, 1969).

Having classified the child's abilities relative to his/her chronological peers, relative strengths and weaknesses must be determined. The child's mean scaled score is then calculated and is employed (in the same manner as above) to determine whether the subtest indicates a relative strength, a relative weakness, a relative major strength, or a relative major weakness.

As each subtest represents a different ability, each subtest name is employed as a descriptor, which may be classified as a strength, weakness, average ability, relative strength, relative weakness or relative average ability. When categorizing subtests according to the above definitions, they are also added to the appropriate list of descriptors.

The ITPA subtest scores are combined to allow assessment of:

- the auditory-vocal channel (the corresponding descriptor is shortened to auditory-channel)
- the visual-motor channel (the corresponding descriptor is shortened to visual-channel)
- the receptive process
- the associative process
- the expressive process
- the representational level

- the automatic level

The various subtests for each channel, process and level are as follows:

auditory channel: auditory reception, auditory association, verbal expression, grammatical closure, auditory sequential memory, auditory closure, sound blending
visual channel: visual reception, visual association, manual expression, visual closure, visual sequential memory
receptive process: visual reception, auditory reception
associative process: visual association, auditory association
expressive process: verbal expression, manual expression
representational level: visual reception, auditory reception, visual association, auditory association, verbal expression, manual expression
automatic level: grammatical closure, visual closure, auditory sequential memory, visual sequential memory.

For each channel, process and level, the system determines the child's mean scaled score. (Not all of the subtests within a particular channel, process or level need have been administered.) Because each subtest has a mean scaled score of 36, the mean of each channel (process or level) is also 36. Similarly, one might assume a standard deviation of 6 for each channel (process or level). Alternatively, if one considers the visual channel subtests to be all measures of visual perception (and thus the subtests are not independent), one can apply the Spearman-Brown formula (Winer, 1962) to reflect the added reliability due to increased test length. It is this strategy that has been employed in the past in Edexc 450 and is also adopted here.

Using the child's mean scaled score and the appropriate standard deviation, the system determines whether the particular channel (process or level) represents a relative strength, a relative weakness, or neither. In each case, the channel (process or level) name is added to the appropriate list of descriptors. If a channel (process or level) represents a relative weakness, the appropriate further assessment flag is also set to true.

After assessing intellectual ability, the child's general achievement within the areas of reading, spelling and arithmetic is examined. For each of these three subjects, the user is asked to supply the abbreviated test name, the administration date, the type of test score, and the child's score.

If the appropriate test or subtest has not been administered this is noted in the report, and, of course, the corresponding further assessment flag will still be true. For each of these three academic areas, the expert system determines whether the child's performance is below average, average, or better. If the child's score is in the low-average range (i.e. 2/3 of a standard deviation below the mean) or worse, then further assessment is warranted. If the child's achievement is better than average (i.e. one standard deviation above the mean), the descriptor (i.e. the subject area) is categorized as a strength. Alternatively, a performance in the average range would be added to the list of average ability descriptors. Average or better skills in reading, spelling or arithmetic should be exploited to the child's advantage during remediation and hence are noted here.

Generally, test manuals specify the test's mean and standard deviation. In the case when a test score is an age equivalent, the system converts it to a quotient. Assuming a child's achievement age should equal his/her chronological age, the quotient mean is 100. In this case, a standard deviation of 15 is arbitrarily applied. However, for both the Schonell Word Recognition Test and the Schonell Graded Word Spelling Test, this range was found to be too broad. Experience showed that a standard deviation of 12 was found to be more appropriate.

4.5.5 Component: Definitive Level 2

Purpose: Further assessment of reading, spelling and arithmetic skills, as well as general assessment of the child's communication skills (e.g. language and writing).

Information Sources: Standard tests in each of the aforementioned areas.

It is within this component of the McLeod Educational Diagnosis Model that the scope of the system's expertise is restricted to reading. Therefore, if further assessment is deemed to be necessary in any other area (e.g. spelling, arithmetic, language, handwriting), the system makes appropriate final recommendations. When the child's arithmetic, spelling or language skills require further assessment, the system recommends two potential tests. However, no further guidance is offered.

On the other hand, if the child's reading skills warrant further assessment, the user is asked to administer an individual reading comprehension test. The system recommends either the Neale, the Durrell, or the Gap. The score from this test is then used to determine whether the child's comprehension is adequate, a strength or a weakness. This is accomplished by computing the average range (i.e. the test mean plus or minus one standard deviation) for the particular test. If the child's comprehension score is below this, further assessment of comprehension is recommended. As always, COMPREHENSION is added to the appropriate list of descriptors.

Secondly, by comparing the child's comprehension score to the child's previously provided reading achievement score, the system can estimate whether comprehension is a relative strength, a relative weakness or in line with the child's overall reading ability. This can only be done when the two measures are converted to the same type. For example, they might both be z-scores or both be quotients. Because the majority of scores are given as age equivalents and hence converted into quotients, this section is currently executed only when both scores are quotients. The actual cut-offs are as follows. If

comprehension quotient x 100 / reading achievement quotient is greater than 110, comprehension is considered to be a relative strength. If on the other hand, it is less than 90, it is a relative weakness. These figures are approximations to those employed in previous diagnoses. As always, the appropriate descriptors are updated.

4.5.6 Component: Definitive Level 3

Purpose: To assess the child's behaviour, emotional status, social and medical problems.

Information Sources: This generally involves consultation with specialists.

Normally within this component, a diagnostician would assess the child's behavioural, emotional and social problems. This generally would involve consultation with or referral to various specialists. If the further assessment flag FA-BEHAV-EMOT is true (i.e. behavioural or emotional problems were noted at the Retrospective stage), further assessment of the child's behaviour is recommended here.

In this system, medical problems are restricted to eyesight and hearing. In level 3 of the Retrospective stage, FA-VISION was set to true if it was suspected that the child had defective eyesight, yet had never had an eye examination. Here, FA-VISION prompts the system to recommend an eye test. A similar recommendation is made if FA-HEARING is true.

4.5.7	Component:	Analytic Level 1
	Purpose:	Further assessment of basic educational skills such as reading, spelling and arithmetic.
Information Sources:		Standardized tests supplemented by informal assessment.

By this point, assessment has been restricted to reading difficulties, with the diagnosis being guided internally by three further assessment flags: FA-DECODING, FA-LETTERS, FA-SOUND-BLENDING.

If reading problems were suspected at the Definitive stage, FA-DECODING was set to true. Consequently, the assessment of reading generally begins with the administration of an individual reading test which allows the teacher to analyze the child's decoding errors made in context. The system recommends the Neale, the Durrell or the Gates-McKillop. If the child's score on such a test is above average, further assessment of decoding skills is not necessary. Of course, assessment continues if the child's decoding skills appear to be below average. It was also decided to investigate the child's decoding skills further when his/her score fell within the average range, because earlier assessment the child's general reading achievement must have indicated low-average performance or worse. From the child's score, the system determines whether the descriptor DECODING-IN-CONTEXT is to be classified as a strength, average ability or a weakness.

Because the Neale was the generally accepted test in the examined Edexc 450 files, specific production rules exist for this test. For each paragraph the child reads on the Neale, the system asks for the paragraph number and the total number of errors. If the latter is non-zero, the user is to enter the number of word substitutions, additions, omissions, refusals and reversals. The system then determines the number of mispronunciation errors. If this number is non-zero, the system then asks for the number of substitutions at the beginning, in the middle and at the end of words.

After this information has been collected for each paragraph, the system examines the total number of errors of each type. If the total number of reversals represents more than 10% of the total number of errors, an appropriate message is printed and REVERSALS is added to the descriptor list of relative weaknesses. Of course, if few errors were made, the 10% criteria would be meaningless. However, administration of the Neale is not to be terminated until the child makes more than twelve errors on a single paragraph, thus usually guaranteeing a sufficiently large sample.

Similarly, if the number of substitutions made within words accounts for more than 10% of the total errors, these mistakes are examined further. The system determines whether the child is making a large proportion (arbitrarily, 40% or more) of such errors at the beginning, in the middle, or at the end of words.

The third type of error analysis performed on the Neale data determines whether the child is relying on context clues. If the child is relying heavily on context, a large proportion of errors might be omissions, additions or word substitutions. Although this may not be the only cause for such errors, it is one of the few available means of determining context reliance. Hence, if the child's total number of additions, omissions and substitutions is more than 30% of his total errors, the system adds CONTEXT to the list of relative weaknesses. (The system's cut-offs can easily be modified, if the examination of additional cases demonstrates these to be inadequate.)

Within this diagnostic component, there is a second major production rule which is triggered by the variable FA-DECODING. If further assessment of decoding skills is warranted, the system will suggest the administration of a word analysis or phonics test such as the Domain. The expert system contains specific rules to handle the large volume of data obtained from the Domain. These rules are, however, very general and are easily modified for other phonics tests. Because this is the only standardized word analysis test administered by Edexc 450 students, the rules are currently specific to the Domain.

Currently, the system asks the user to specify which subtests were administered. From this information, the system determines which phonic information to request and how many trials the child was given in each case. For example, subtest one contains three words for each of the sixteen initial consonants. It also contains nine different final consonants and all five short vowels. The system knows which consonants and vowels are tested in subtest one and the number of times each is presented. This knowledge is available to the system for each of the four subtests.

For each appropriate grapheme type -- initial consonants, initial consonant blends, final consonants, final consonant blends, short vowels, long vowels, vowel blends -- the system requests a list of the child's errors. From this and the general information about the Domain, the system determines the child's level of mastery for each particular grapheme-phoneme association. For example, if both subtests one and two were administered, the child was given 6 words starting with the letter 'b'. Two errors implies that the child has mastered the initial consonant 'b' at the 67% level. If the child's mastery level is less than sixty percent, the letter is indicated as a significant problem. On the other hand, if the level of mastery is between 60% and 80%, it is still considered to be a difficulty. After all initial consonants have been examined, the system indicates which initial consonants should be taught. Letters not mastered at the 60% level are suggested first, followed by any others not mastered at the 80% level.

This format is repeated for final consonants, initial consonant blends, final consonant blends, short vowels, long vowels and vowel blends (depending on which subtests were administered). Hence, for each grapheme type, we have ascertained whether the child has problems. Furthermore, we have pinpointed the particular instances with which the child has difficulties. The system decides whether the child's knowledge of each type is adequate (i.e. all letter or letter combinations are mastered at the 80% level), in which case the list of average ability descriptors is updated. Alternatively, the grapheme type is added to the list of weaknesses; the corresponding descriptors are INITIAL-CONSONANTS, FINAL-CONSONANTS, INITIAL-CONSONANT-BLENDS, FINAL-CONSONANT-BLENDS, SHORT-VOWELS, LONG-VOWELS, VOWEL-BLENDS.

For each letter or letter combination not mastered at the 60% level, the system checks whether there is one particular response accounting for the majority (i.e. more than 50%) of the child's errors. If so, this particular confusion is noted in the diagnostic report. The following case illustrates the point:

subtest administered: 3
vowel blend: 'all'
number of trials: 3
child's errors: 'el' 'il' 'el'
mastery level: 0%
confusion: The vowel blend 'el' accounts for approximately 67% of the child's errors. Hence the pair ('all'-'el') is considered a confusion.

Because conventional phonetic nomenclature is not suitable for most computer terminals and printers, the following notations are adopted here:

- Initial consonant and consonant blends are represented by the letters themselves, e.g. 'b', 'dr'.
- Final consonants and consonant blends are prefixed by '-', e.g. '-b', '-ch'.
- If the child separates a consonant or vowel blend into two separate sounds, this is indicated by a hyphen, e.g. 'sh' would become 's-h'.
- Short vowels are represented by the single letter, e.g. 'a'.
- Long vowels are represented as follows: 'a-e', 'e-e', 'i-e', 'o-e', 'u-e'.
- Vowel blends are as they appear on the Domain summary chart, with long vowels represented as above, e.g. 'ow(o)' would be translated to 'ow=o-e'.
- Although phonics sounds such as â, ő do not appear on the Domain, they may be included in the child's answers. The convention employed here is to place the accent symbol beside the letter (as if the symbol had slid off the top of the letter). Hence, "â" becomes "a>" and "ő" is "o:".

In addition to specifying which areas represent a weakness or adequate knowledge, the system detects relative weaknesses. This information is particularly valuable when a child is experiencing difficulties in several aspects of word analysis, which is often the case.

Because the system knows which subtests were administered, it can calculate the percentage of trials for each grapheme type. For example, if only subtests one and three were presented, 14% percent of the presented words contained initial consonants. If the child, however makes 20% of his/her errors on initial consonants, initial consonants represent a relative weakness. However, if only subtest one was administered, 31% of the words contained initial consonants. In this case, if the percentage of initial consonant errors is 20%, initial consonants are not a relative weakness. Therefore, for each grapheme type the system can determine whether the child's knowledge is average, a weakness or a relative weakness. The system's lists of descriptors are updated accordingly.

Still further information can be extracted from the Domain. Each time the child makes an error on an initial or final consonant, the system checks whether the substituted response is a consonant blend. If a high proportion of errors are consonant blend substitutions, this should be noted in the diagnostic report. However, if the child has made relatively few errors on initial consonants, a high percentage of errors of one type is not very meaningful. To ensure a sufficiently large sample size, further analysis is undertaken when the child's percentage of errors on a particular grapheme type is greater than half the potential percentage. For example, when subtests one and three are administered, 14% of the presented words contain initial consonants. If the child makes only 5% of his/her errors here, the system is not concerned with the percentage of consonant blend substitutions. If, however, the child makes 12% of his/her errors on initial consonsants, the situation bears further analysis. If, under these circumstances, more than 30% of the child's errors on initial consonants are consonant blends, the system outputs this as an area of relative weakness; the corresponding descriptor is INITIAL-CONSONANTS->CONSONANT-BLENDS. The '->' symbol represents the direction of transformation. Therefore the descriptor SHORT-VOWELS->LONG implies that the child tends to substitute long vowels for short; in other words, short vowels are transformed to long.

The system detects several different problems of this nature. In each case, the corresponding descriptor is added to the list of relative weaknesses. The possible descriptors are as follows (further explanation is provided in section 4.4):

initial-consonants->consonant-blends
final-consonants->consonant-blends
initial-consonant-blends->consonants
final-consonant-blends->consonants
short-vowels->long
short-vowels->vowel-blends
long-vowels->short
long-vowels->vowel-blends
vowel-blends->short
vowel-blends->long

From the word analysis test, the system recognizes the likelihood that the child's knowledge of individual letter names and sounds is inadequate. In which case, further assessment is warranted; this is indicated by the further assessment flag FA-LETTERS. If the child has difficulty with a quarter of the initial consonants on the Domain, FA-LETTERS is set to true. Under these circumstances, the user is asked to administer four informal tests wherein the child is to:

- Identify by name all 26 capital letters.
- Identify by name all 26 lower-case letters.
- Identify by sound all 26 capital letters.
- Identify by sound all 26 lower-case letters.

Also within this component, the system determines whether further assessment of the child's ability to blend sounds is required. For example, if the sound blending subtest of the ITPA was administered and the child's score was within the average range or better, no further assessment is necessary. Otherwise, the user is asked to administer a test to assess the child's sound blending skills. One appropriate test is the sound blending subtest of the Gates-McKillop. For each grade level, the Gates-McKillop specifies what is considered an adequate performance. For example, a grade three pupil should be successful on at least four of the 23 words; a score greater than eight would represent a strength. Therefore, from the number of correct items, the system ascertains whether the child's ability is average, above, or below. SOUND-BLENDING is then added to the appropriate list of descriptors.

4.5.8 Component:	Analytic Level 2
Purpose:	To assess auditory and visual perceptual skills, motor skills, as well as further assessment of language skills.
Information Sources:	Both standardized tests and informal assessment techniques.

If the system noted that the child may have an auditory perception problem (e.g. FA-AUD-PERCEPTION is true), it recommends the administration of a test of auditory discrimination, such as the Wepman.

Currently the system contains specific rules for the Wepman, in which case the system will ask for the Y score (the number of errors made on pairs of identical words) and the X score (the number of errors made on pairs of different words). If the Y score is greater than one, the test is not considered valid. Alternatively if the child makes more than three errors on pairs of different words he/she is deemed to have difficulty discriminating between similar sounds. In this case, AUDITORY-DISCRIMINATION is categorized as a weakness. If the child makes fewer errors, AUDITORY-DISCRIMINATION is added to the list of average ability descriptors.

If FA-VIS-PERCEPTION is true, the system recommends the administration of a test of visual perception. Similarly, if previous responses had suggested either fine or gross motor difficulties, further assessment is recommended here. However, due to the limited scope of the present study, no additional guidance or analysis takes place. Within this component, a diagnostician might also undertake further assessment of language problems. However, this is not appropriate here as a referral for further assessment was recommended at the Definitive stage, if there was reason to suspect language problems.

CHAPTER FIVE

AN EVALUATION OF THE SYSTEM'S PERFORMANCE

5.1 The Format of the Experiment

Evaluation of the system's performance is a crucial portion of the implementation phase. Educational diagnosis by a human is implicitly assumed to be both reliable and valid. The criteria according to which computer-guided diagnosis is judged must be related to human diagnoses; the expert system must produce reliable and valid diagnoses. Obviously the computer, as a diagnostician, is consistent and reliable; for two identical sets of input data, it will produce two identical diagnostic reports. However, is the output valid?

An appropriate means of determining the validity of the computer-produced diagnostic reports must be devised. Currently, the only alternative is to compare the expert system's findings to what the human diagnosticians believe to be true. Eventually, however, an expert system's validity might well surpass that of human diagnosticians, because ultimately the expert system may have the advantage of greater experience, cumulatively improved analysis of data, as well as a consistent and reliable memory.

For this study, it was decided to base the comparison upon previous diagnoses, similar in nature to, but not the same ones as, those employed during the design and implementation stages. Appropriate cases were selected from

Edexc 450 files throughout the 1972-1974 period. The same criteria were applied as before; the children must be between the ages of eight and ten years and experiencing reading difficulties. The files were to be relatively complete, i.e. they must include a report on the child's developmental history from both the school and the parents, as well as the appropriate test scores and a diagnostic or remediation report. Remediation reports include a summary of diagnostic findings and thus can be employed in lieu of a diagnostic report.

Twenty-four files were selected as a basis for comparison. As before, the necessary information from the various tests, school and parent reports was summarized. As these files often contain pre- and post-tests over several academic semesters, summarizing the information beforehand ensured that only original diagnostic information was being employed. A legitimate comparison is only possible if both human and machine are basing their diagnoses upon the same data. A fourth year education student was employed to summarize the Edexc 450 files used at this stage.

For each case, the expert system analyzed the data and printed the resultant diagnostic report. Appendix C contains a copy of each of these reports. The global database is also available for each file, although these have not been included here.

The next step was to compare the computer's diagnostic findings with those of the human diagnostician. Although each Edexc 450 file contained a report of diagnostic findings, direct comparison is not possible, because the human reports are couched in the more qualitative terms to be expected of narrative prose. Hence, the reports from human diagnosticians were encoded in terms of the expert system's descriptors and descriptor classification scheme.

To ensure impartiality, the encoding was undertaken by two other students who had successfully completed Edexc 448 and 449. Each student encoded the 24 files independently. In addition to analyzing the reports in terms of the specified descriptors, they summarized any other important diagnostic findings which pertained to reading.

It is important to ascertain if any information is included in the expert system's report but omitted in the human's, and vice versa. By examining the two sets of descriptors, i.e. that which resulted from the computer-guided diagnosis and the set which resulted from the unassisted human diagnosis, the former can be evaluated. In order to determine if the expert system failed to report any vital findings, it is necessary to examine more than just the descriptors; the summary of the diagnostic reports has also to be examined.

The current expert system is not designed to detect difficulties in specific areas of arithmetic, spelling and language. Such omissions from the system's reports are therefore to be expected. But the system's reports are also clearly missing information regarding reading skills. The expert system does not have the capability to assimilate information concerning deportment, e.g. restlessness, laborious reading and disregard for punctuation while reading. Although this type of information is important when assessing reading skills, these omissions are not of concern at the moment. The system's performance must be judged in light of the current purpose of the system, and the present pilot system is not intended to produce such diagnostic information. Methods by which such knowledge might be incorporated into future studies are discussed in Chapter 6.

What must be determined is whether the original diagnostic reports contain findings which the system should have detected but did not. For example, the system purports to find phonics difficulties. Therefore the system's capacity in this regard is critically evaluated.

For each of the 24 files included in this experiment, Appendix C contains

- the expert system's diagnostic report.
- the descriptors for the original diagnostic report.
- a summary of other diagnostic information contained in the original diagnostic report.
- a comparison of the descriptors classified as relative strengths and relative weaknesses by the two encoders and the expert system.

Two copies of the descriptors are included for each of the original Edexc 450 diagnostic reports, as each file was examined independently by the two encoders. The appendix also includes sample reports from the Edexc 450 files, to give the reader an idea of the format and variability of such documents. For the first of these sample reports, Appendix C also contains an encoding of the report in terms of the expert system's descriptor classification scheme.

5.2 The Results

From the sample encoding included in Appendix C, it is clear that this particular encoding is an accurate reflection of the diagnostic report. However, not all diagnostic reports are as well written or precise as this particular example. When the diagnostic findings were not stated precisely, the encoders experienced difficulty classifying descriptors. In fact, they often classified descriptors differently. For example, when a diagnostician remarks that a child "is experiencing difficulties", it is unclear whether the skill in question should be represented as a weakness or a relative weakness. Too often, the diagnostic reports do not contain further clarification. If test results are given, either in the body of the report or in an appendix, these can be employed to aid in the encoding. By comparing the two sets of descriptors for each Edexc 450 report, it is clear that encoding such reports is not a simple task. Agreement is poor when the diagnostician has employed vague terminology or when only a summary of diagnostic information was available.

When the encoders encountered diagnostic information pertaining to reading (including behaviour and deportment) for which there was no appropriate descriptor, such information was summarized. For a third of the reports, the encoders supplemented the descriptors with summarized information. These additional summaries are minimal, usually consisting of a single observation. Furthermore, the summarized information generally is contained in the expert system's report, although there is no appropriate descriptor. For example, if the child is confusing 'b' and 'd', this is noted in the system's diagnostic report but there is no descriptor for 'b-d' confusions. The paucity of the encoders' summaries suggests that the existing descriptors are sufficient for the representation of reading diagnosis, as practised in Edexc 450.

In order to evaluate the expert system's performance, the system's classification of descriptors must be compared with those of the two encoders. It was decided to compare the descriptors classified as relative weaknesses and relative strengths, as these are two of the largest categories. (Interpretation and potential categories for each descriptor are contained in section 4.4.) For each file, Appendix C contains tables illustrating the agreement between the system and the two encoders with regards to the classification of relative strengths and relative weaknesses.

To interpret these statistics it is first necessary to compare the two encoders. Despite the fact that both encoders analyzed the same reports (not just the same data), agreement between the two encodings is approximately 50%.

Examination of the two encodings revealed the following:

Total Number of Descriptors Noted as Relative Strengths

Noted by Encoder #1 (not noted by Encoder #2):	13
Noted by Encoder #1 and #2:	16
Noted by Encoder #2 (not noted by encoder #1):	7

Total Number of Descriptors Noted as Relative Weaknesses

Noted by Encoder #1 (not noted by Encoder #2):	44
Noted by Encoder #1 and #2:	49
Noted by Encoder #2 (not noted by Encoder #1):	46

Hence, the two encoders agreed upon the classification of 65 descriptors. In total, encoder #1 noted 122 relative strengths and relative weaknesses. In other words, encoder #2 agreed with 53% of encoder #1's classifications.

The lack of agreement between the two encodings makes it difficult to judge the expert system's performance. Comparison of the system's classification with each encoder revealed the following:

Total Number of Descriptors Noted as Relative Strengths

Noted by Encoder #1 (not noted by the expert system):	9
Noted by Encoder #1 and the expert system:	20
Noted by the expert system (not noted by Encoder #1):	37

Noted by Encoder #2
(not noted by the expert system): 5

Noted by Encoder #2 and the expert system: 18

Noted by the expert system
(not noted by Encoder #2): 39

Total Number of Descriptors Noted as Relative Weaknesses

Noted by Encoder #1
(not noted by the expert system): 48

Noted by Encoder #1 and the expert system: 45

Noted by the expert system
(not noted by Encoder #1): 108

Noted by Encoder #2
(not noted by the expert system) 56

Noted by Encoder #2 and the expert system: 39

Noted by the expert system
(not noted by Encoder #2): 114

Of the 29 descriptors classified as relative strengths by encoder #1, 20 were also noted by the system; hence, the expert system agreed with 69% of the relative strengths noted by encoder #1. Similarly, the expert system agreed with 78% of the relative strengths classified by the second encoder.

The agreement, however, is less for relative weaknesses where the potential number of descriptors is higher; only 20 of the system's descriptors can be categorized as relative strengths, whereas there are 42 potential relative weaknesses. Of the 93 relative weaknesses classified by encoder #1, the expert system noted 45; an agreement of 48%.

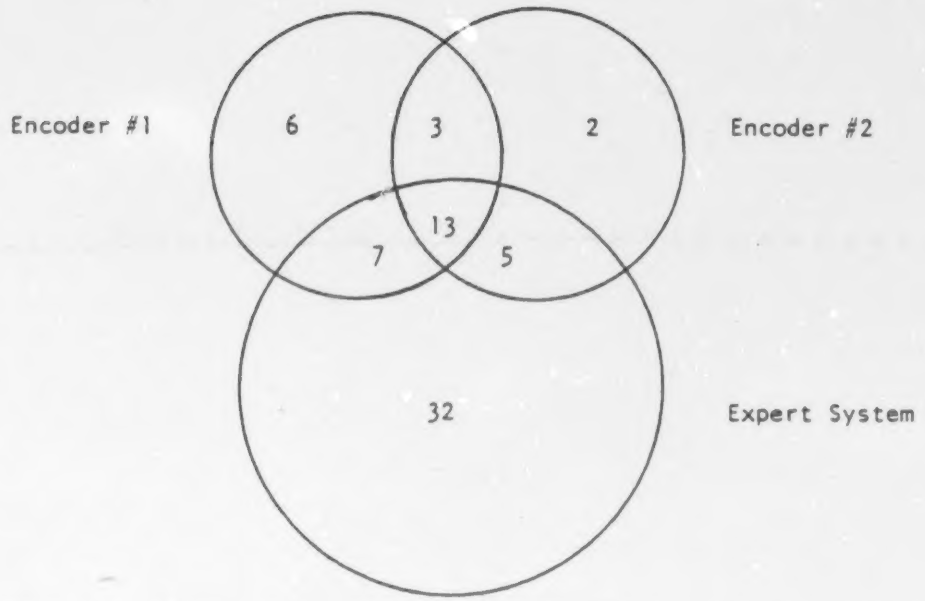

Encoder #1
6
3
2
Encoder #2
13
7
5
32
Expert System

Figure 4: Total number of descriptors noted as relative strengths

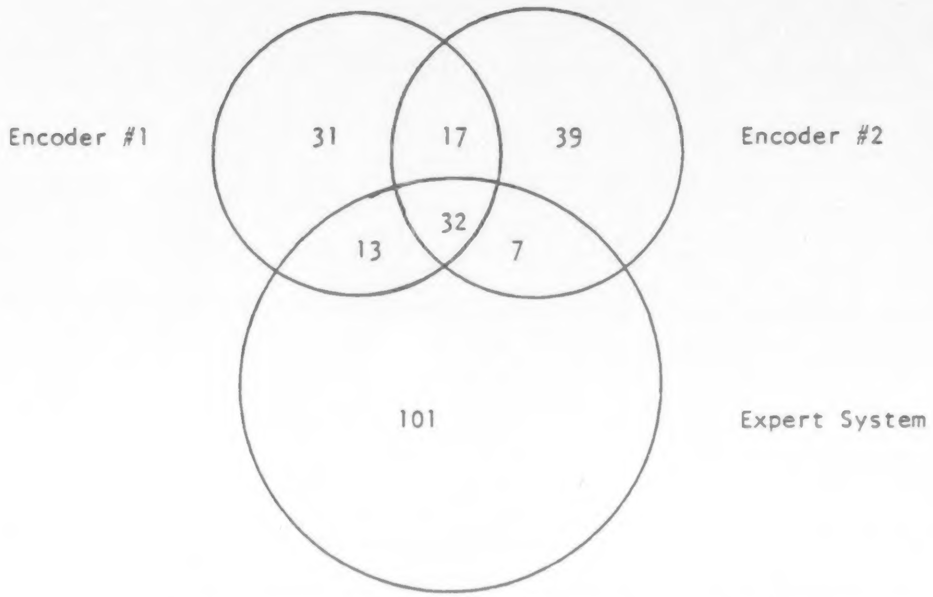

Encoder #1
31
17
39
Encoder #2
32
13
7
101
Expert System

Figure 5: Total number of descriptors noted as relative weaknesses

In actual fact, the expert system and encoder #1 agreed upon the classification of 65 descriptors. Hence, the expert system agreed with encoder #1 the same number of times as encoder #2 had agreed with encoder #1.

In all cases, the expert system's report contains information not included in the original report. This is not surprising; an expert system has the ability to extensively analyze test results and to do so quickly and accurately. For example, the child's responses on the Domain are analyzed extensively, including the exact percentage of errors on each grapheme type, the percentage of errors for each type of substitution, and the percentage of times each particular substitution occurred (e.g. 'b' for 'd'). From this data, the system can determine whether the difficulty is truly a relative weakness -- relative to the child's other skills and difficulties. A human diagnostician does not have the time to perform such calculations. Consequently such information is generally lacking in diagnostic reports.

This situation does not arise just with respect to the Domain. In the Edexc 450 reports examined, few diagnosticians commented upon the child's level of achievement on the ITPA's processes, channels or levels. To determine the child's performance on these aspects of the ITPA requires a few additional calculations which are easily performed by the expert system.

Hence, it is not surprising that the expert system's reports contain information not included in the humans' diagnostic reports. The system has the tremendous advantage of being able to perform numerical calculations quickly and accurately. Furthermore, data can be analyzed with regards to many different aspects, as is the case with the Domain. The analysis currently performed by the expert system, although possible manually, would be extremely tedious and time-consuming, and represents an unreasonable amount of work for a human diagnostician.

In some cases encoded Edexc 450 reports contain descriptors classified as relative strengths or relative weaknesses which are not categorized as such in the expert system's reports. For example, in the second encoding of file #430, three of the ITPA subtests are categorized as relative weaknesses. In fact, they represent areas of absolute weakness; these three subtests do not represent areas of weakness relative to the child's mean scaled score on the ITPA. Difficulties of this nature arise because diagnostic reports are often imprecise. Many of the reports examined herein did not distinguish between strengths and relative strengths, weaknesses and relative weaknesses.

This problem does not arise only on the ITPA; it is also prevalant with regards to the Domain. For example, in files 503, 510 and 529 (among others) the descriptors INITIAL-CONSONANTS and FINAL-CONSONANTS have been classified as relative weaknesses, but not weaknesses. From an examination of the child's performance on the Domain, it is clear that these skills are weak relative to the child's chronological peers. Such skills may also represent areas of relative weakness, but this does not appear to be the case.

File #503 illustrates this point. Both encoders classified Randal's knowledge of initial and final consonants as an area of relative weakness. In fact, only two initial consonants were not mastered at the 80% level compared to nine vowel or vowel blends which did not meet this criteria. In comparison to Randal's other phonic skills, neither initial nor final consonants were a relative weakness. Nor was Randal's knowledge of consonants a relative weakness in comparison to his other reading skills; his general achievement in reading, as measured by the Schonell, was below average. Furthermore, the Neale indicated below average ability when reading continuous prose, and poor reading comprehension.

There are other reasons for disagreement between the encodings and the expert system's reports. The expert system is programmed to detect phonic information only on the Domain, whereas the human diagnostician may note such difficulties on a variety of tests. For example, the report contained in file #450 comments on the child's phonic skills, although no word analysis test was administered. The expert system's report cannot contain the corresponding information, as the system never had an opportunity to assess the child's knowledge of phonics.

Similarly, the diagnostic report in file #505 discusses the child's performance on the ITPA, and the two encoders classified the ITPA subtests accordingly. The ITPA, however, was not administered at the time of assessment. It had been administered a few months earlier by another agency, and it is these results which are discussed by the human diagnostician. When the expert system requests data concerning previous testing, it does not obtain subtest scores and hence cannot classify the corresponding descriptors.

From the results contained in Appendix C, it is apparent that the expert system's diagnoses are accurate. At times, the system may provide too much information. For example, when the child is experiencing severe difficulties with single consonants there may be little value to informing the teacher that the majority of the child's errors on vowel blends are short vowel substitutions. Although this information will prove useful in the remediation of vowel blends, such instruction is generally not undertaken until single consonants and vowels are mastered. The system is correct in its classification of such information; perhaps such data should not have been collected, and if gathered perhaps it should have been omitted from the diagnostic report. The expert system currently reports all diagnostic findings whereas a human diagnostician might report only the most relevant for short term remediation. Modifications of this nature are discussed in Chapter 6.

From the reports contained in Appendix C, it is clear that the system's output is consistently good. In contrast, diagnostic reports prepared by humans vary dramatically in terms of style, format, readability, relevance and accuracy. Some are better than the system's reports; many are inferior.

CHAPTER SIX

CONCLUSIONS

6.1 Contributions

The intent of this thesis was to examine the feasibility of computer-guided educational diagnosis. Feasibility has been demonstrated by designing and implementing an expert system to assist in the diagnosis of reading difficulties. From the results discussed in section 5.2, it is apparent that the current system provides sufficient advice to guide the diagnostician from the first level of the Retrospective stage through to the second level of the Analytic stage. Moreover, the resultant diagnostic report contains accurate information upon which to base a prescription. Although the ultimate system, as presented in chapter 2, has not been developed, the system discussed here is operational and provides the fundamental working basis upon which to build future systems. Many directions for expansion are discussed in section 6.2.

The system is designed to allow future extensions and modifications; the production system format lends itself well to change. Because the information concerning diagnostic procedures is encoded into separate production rules, this information is easily modified. When a rule is altered, added or deleted, it impacts another only through its changes to the global database. At no point does a rule ever say "now execute rule X"; rules are self-contained. Hence, rules can be modified, added or deleted without making another rule "wrong". By incorporating new rules, the previous ones may be executed less often, but they are still "correct" rules. Consequently, the use of production rules allows one a great deal of flexibility.

Not only is each rule a separate unit, the system's production rules are partitioned according to the McLeod Educational Diagnostic Model. Each component of the model can be viewed in isolation, again passing information only through the values stored in the global database. In other words, the production rules of each component simulate the expert's behaviour for that particular component, independent of what comes before or what follows. All necessary information regarding previous behaviour is stored in the data structures. Again, this modularity is an asset when testing, modifying and extending the system.

One reason for selecting a production system format for an expert system is the fact that the three system components can be altered relatively independently. Therefore, future modifications and extensions should be enhanced by the modularity of the system's design at three levels:

1. The production system consists of three independent components.
2. The McLeod Educational Diagnostic Model is partitioned into components.
3. Each production rule is a separate "condition-action", independent of all other rules.

Consequently, not only is the expert system in operation and producing appropriate diagnostic reports, it is truly extendable.

The development of this expert system allows for the evaluation of the design and implementation stages. In particular, the decision to base the production rules upon previous diagnoses should be evaluated. Should this approach to the development of production rules be employed for future extensions?

The creation of rules to mimic experts' behaviour is not a simple task.

> "To develop an expert system, AI [Artificial Intelligence] researchers often spend years picking the brains of experts, trying to extract and then structure the elusive knowledge that is the basis of the expert's skill -- a process they call 'knowledge engineering'." (Business Week March 8, 1982; p. 68).

Instead of reflecting one expert's opinion, it was decided to base the rules upon previous diagnoses. Hence the diagnostic decisions, reflected in the production rules, are based upon observed characteristics of actual cases, not stereotypes. This alone ensures a more accurate performance by the expert system. Furthermore, the opinions of many diagnosticians are included. The Edexc 450 files examined during the design phase reflect several experts' and many university students' views of diagnostic procedure. The result is a less biased set of rules.

Despite its time-consuming nature, employing previous diagnoses as a basis for the production rules has many advantages. However, to obtain a true picture of educational diagnosis, a large number of cases need to be examined. The more diagnoses examined, the more accurate will be the resultant rules. By examining thousands of documented cases, many experts' opinions can be incorporated. This is particularly beneficial in fields lacking agreement among the experts. Although a limited number of files was examined here, the results indicate that this approach to developing production rules is both feasible and advantageous.

There are also ancillary benefits to this approach. By examining the Edexc 450 files, it can be determined to what extent diagnosticians adhere to the McLeod Educational Diagnostic Model. In other words, is the model a true reflection of diagnostic procedures in practice? The answer appears to be affirmative. Diagnosticians, however, are not restricted to executing one model component at a time. Although diagnosis proceeds from the Retrospective Stage through to the Prescriptive Stage for each area of concern, the diagnostician may be assessing the child's reading skills at the Analytic stage and the child's general arithmetic ability at the Definitive Stage within the same diagnostic session. With this flexible interpretation of the model, the McLeod Educational Diagnostic Model appears to be a valid reflection of diagnostic procedures as they are as well as how they should be practiced.

At each step of the diagnostic process, a variety of information is considered. In fact, the diagnostician may be unaware of the many factors which contribute to a decision. The development of an expert system's production rules helps to identify these factors. In order to develop production rules which successfully mimic the diagnostician's behaviour, all diagnostic decisions must be made explicit: each factor which contributes to a decision must be specified. When the expert system is unsuccessful at modelling human experts' behaviour, it indicates that vital information has been omitted from the production rules. The rules are then modified accordingly. The system's ultimate success at simulating human experts in a variety of cases suggests that the system is examining all necessary information and is doing so correctly.

By knowing exactly what human experts do at each step, precise guidelines can be specified for less experienced diagnosticians. Hence, the development of production rules helps to eliminate much guesswork. Eventually, a set of production rules should represent a detailed description of logical diagnostic procedures.

The expert system can also bring to light deviations from accepted diagnostic practice. By examining previous diagnoses, unfounded diagnostic decisions can be identified. For example, most diagnosticians are aware that decisions should never be based upon a single task or test; despite this, lack of time often results in ill-founded diagnoses. As an illustration, consider the first subtest of the Domain. If the child substitutes a 'd' for 'b' on one word, this is not adequate evidence of 'b-d' confusions. It may be sufficient reason to investigate the child's knowledge of the letter 'b' further. When diagnostic decisions of this type are common, it indicates that inexperienced diagnosticians require further guidance.

6.2 Current Limitations and Future Research

In the previous section, some of the inherent difficulties in building expert systems are mentioned. It is a formidable task to formulate precise rules which accurately reflect the decision-making procedures of various experts. A prerequisite is the selection of experts. Within a controversial field such as learning disabilities the opinions of all experts cannot be incorporated initially. Instead, the system must be designed to be both flexible and modifiable. This is essential if the expert system is to be valuable over time and across various experts' domains.

The modular nature of the system's design allows the incorporation of many experts' opinions. Production rules can be modified to reflect the current theory. If the human diagnostician does not subscribe to a particular theory, the system can ignore the corresponding production rules. In other words, the user can have the option of specifying those educational theories to be incorporated into the diagnostic process.

For the system developed herein, only local cases and experts were consulted. Furthermore, the examined cases were restricted to previous diagnoses that had been made between 1971 and 1974. This automatically restricts test selection, as well as the format and type of diagnostic finding reported. The restrictions imposed here are largely a reflection of resource constraints. Given adequate time, research funds, and programming assistance, collaboration between educators and computer scientists could result in the diagnostic expert system discussed in chapter 2. This system would be capable of guiding teachers through the various stages of diagnosing learning difficulties, culminating in a comprehensive diagnostic report and prescription. The system designed and implemented here is a first step.

Before the system is suitable for general use, a more elaborate interface is required. Although the entire system has been designed with the eventual interface in mind, its actual development still remains a time-consuming task. The existence of a comprehensive system interface will remove the occasional need for the diagnostician to enter data in a LISP-compatible format; the interface will convert the entered information to the required form.

The incorporation of the system interface will also facilitate the handling of pending information. When information is requested but not yet available, the diagnostician is to enter 'P' or 'PENDING'; the appropriate data structure in the global database is marked accordingly. Execution will continue as before, terminating when no production rule is considered appropriate for execution. The diagnostician is then provided with a summary of what information is pending. The data structures are reset and the control structure terminates the entire interaction.

By employing the above approach, the implementation of the system's interface will have minimal impact upon the control structure. Furthermore, the interface, which is part of the control structure, is completely independent of the system's production rules and global database, neither of which will require modifications.

Additional production rules are required before the system is generally applicable beyond the currently restricted age and subject range. It is important to develop a comprehensive set of rules for diagnosing reading difficulties, before expanding into other subject areas. This will include an expansion of the age range. It must also correct the omissions noted in section 5.2. For example, behavioural information should be incorporated. This could take the form of a checklist, to be completed by the diagnostician after each session with the child. Assimilating information provided in this format is relatively straightforward.

To expand the system's diagnostic capabilities within the area of reading will require the examination of many more cases. The system must also handle a variety of tests which means that more recent cases must be considered. Specific rules might have to be developed for particular tests, although the more desirable approach is to develop general production rules capable of handling many tests. For example, when assessing the child's decoding skills while reading aloud, many standardized tests are appropriate, such as the Neale, the Gates-McKillop and the Durrell. Instead of separate rules for each of these tests, general rules which ask for the necessary information, analyze it and assimilate it should be developed. This has been done somewhat within the current system, but not to the extent required. To develop such general production rules, the precise relationship between information in two different tests must be determined; this appears to be a major task. One alternative is to employ factor analysis to determine factor scores for the various tests. From this data, general rules which encompass all of the vital information can be developed. The system will still have to be cognizant with specific tests, in order to make appropriate recommendations. By making the production rules as general as possible, it is unlikely that the system will be rendered obsolete by the introduction of new standardized tests.

Once the system's interface has been incorporated and a more comprehensive set of production rules developed, the system can be tested in a more general setting. If the system is to be placed within the regular school environment, however, many improvements are desirable.

For example, the amount of time required to enter information must be decreased. This is particularly noticeable when supplying data regarding the student's performance on the Domain. In many cases, the time required to enter information would be decreased by employing a table format on a graphics terminal. The user would first indicate the section of the table or chart for which information is available (by means of a light pen or by moving a cursor) and then type in the data.

Moreover the system must not ask for unnecessary information. Although this rarely happens, occasionally the diagnostician has administered an inappropriate subtest. For example, if the child's performance on the Domain indicates that his/her knowledge of initial and final consonants is seriously deficient, there is little reason to administer a subtest to assess knowledge of consonant blends. If the diagnostician has already done so, the system currently collects the information. Hence, a great deal of time is spent entering the child's errors, when the new data supplies little insight into the child's abilities or difficulties. The Domain's production rules can easily be altered so that unnecessary information is not requested.

Although the system's current output is adequate, it could be greatly enhanced by the use of graphics. For example, when the expert system assesses the child's performance on a particular standardized test, it determines whether the skills tested therein represent a strength, weakness, average ability, relative strength, relative weakness, or relative average ability. The system categorizes the child's abilities by comparing against previously specified criteria. By providing a graphic illustration, the system can demonstrate that such decisions are not clear-cut in practice. The error involved in any measurement should be taken into account. Figure 6 exhibits a possible format for these graphical illustrations.

After incorporating the modifications and extensions discussed above, the system should be suitable for use by resource room teachers when diagnosing a child's reading difficulties. Ideally the system should also provide recommendations regarding remedial activities and instructional techniques. Recommendations should be primarily based upon the system's descriptors, although other information stored within the global database may be considered. For example, the family situation may be unfavourable; in particular, the parents may require advice in coping with the child's disabilities. The development of production rules for the Prescriptive stage of the McLeod Educational Diagnostic Model would take the same format as before, including the examination of many individual cases and commercially available materials. These materials would have to be analyzed in order to associate appropriate descriptors with each. The expert system would then match these descriptors with those in the diagnostic report.

If the system is accessible throughout Saskatchewan, it might be advantageous to develop a battery of standardized

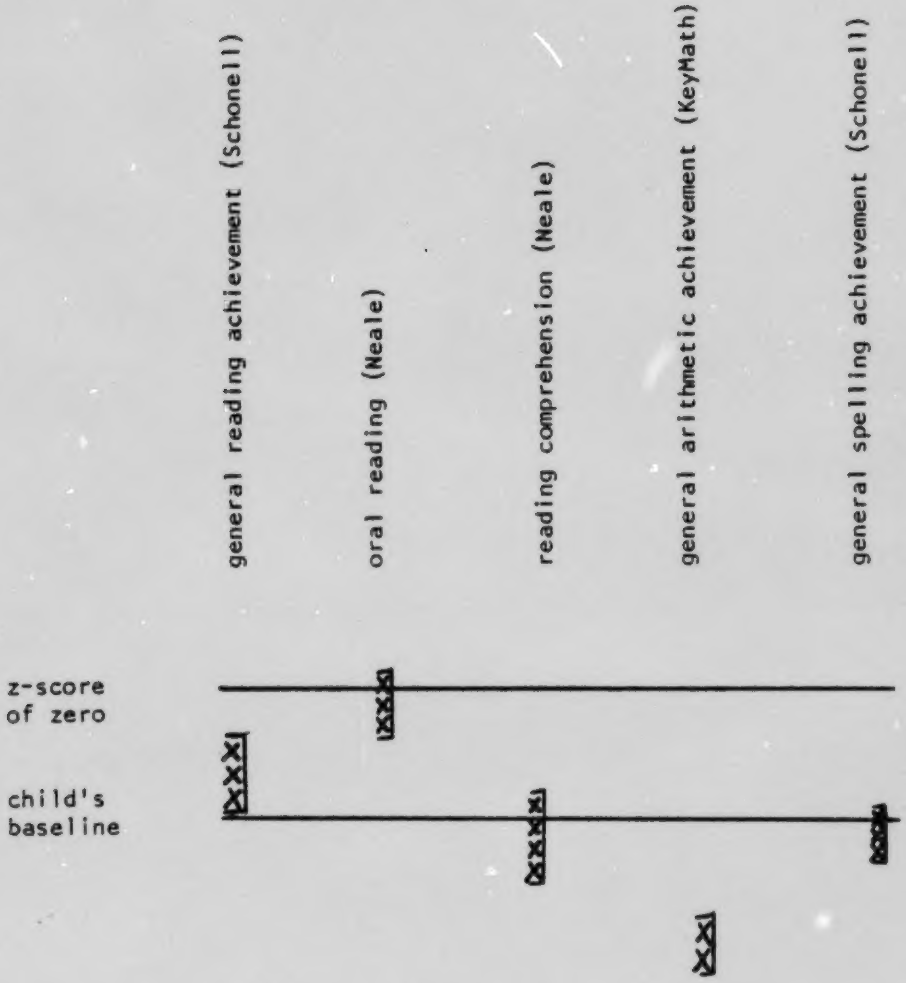


Figure 6: Graphical illustration of the expert's systems diagnostic findings. To facilitate comparison, all test scores are converted to z-scores. Each score is plotted, along with the relative error of measurement.

tests for recommended use. This could include currently available tests, as well as new ones specifically developed, standardized and normed for Saskatchewan.

So far in this section, possible extensions have been discussed as if no implementation problems would arise. At present, the expert system is operational on a DEC 2060. If a "large" computer is used, it is unlikely that implementation problems (most particularly, storage difficulties) will be encountered. However, few resource room teachers have access to such a computer. There are, however, microcomputers within the Saskatchewan school system. If current computer hardware trends continue, the expert system described herein could be implemented on a microcomputer in the near future. Even so, it would be advantageous to transmit all data to a central location for further analysis and consolidated data storage.

Once we have a system to guide the user through the various stages of diagnosing reading difficulties which is suitable for placement within Saskatchewan resource rooms, the system should be expanded to assess other educational problems. At this point, no further system changes need be made; rather additional production rules would be added to the appropriate computer files.

The extensions discussed so far have been to enhance the system's applicability within the school system. These modifications also make the system more appealing both as a teaching aid and a research tool.

By storing all relevant information concerning each case diagnosed with computer assistance, the effectiveness and efficiency of the diagnostic procedures can be evaluated. Similarly, the resulting descriptors and prescriptions can be assessed. The recommended remedial activities and materials can be evaluated to ascertain for which learning difficulties and under what conditions they are most effective.

A diagnostic expert system can also be employed to simulate case studies for the purpose of training diagnosticians. In this way an expert system can supply additional practical experience without involving additional children. Consequently, the system can provide experience when children are unavailable due to illness, vacations or inappropriate hours. The use of computer simulations within the field of educational diagnosis is not new (Hall, 1974; Lerner & Schuyler, 1974). It is a convenient means of familiarizing inexperienced diagnosticians with appropriate diagnostic procedure. Using an expert system in this capacity, however, has tremendous advantages. Because of the system's flexibility, the students can supply any data they choose; simulations need not be restricted to a few prespecified cases. Furthermore, the system can easily be modified to provide explanation concerning which production rule is being applied, and why. Hence, the user would be gaining knowledge concerning the criteria for further assessment at each level and stage of diagnosis.

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APPENDIX A

DEFINITION OF TERMS

average ability
A skill is categorized as an average ability when, compared to the child's chronological peers, the child's ability is within the average range (test mean ± 1 standard deviation).

control structure
The control structure is the system component that governs which appropriate production rule will be applied. In essence, the control structure is responsible for coordinating the entire diagnostic process.

descriptors
The expert system employs descriptors to summarize diagnostic findings. Each descriptor represents either a particular skill or difficulty. A list of system descriptors, along with interpretations and potential categories, is contained in section 4.4.

execute
The execution of a production rule causes the expert system to perform the action specified by the production rule.

expert system
An expert system is an automated consulting system designed to provide the user with expert advice within a particular subject area.

further assessment flags
These system variables indicate areas or skills which warrant further analysis or assessment. They are employed by the control structure in determining rule selection. A list of the further assessment flags which may appear in the system's diagnostic report appears in section 4.4.

global database
The global database is the system component which contains all relevant information pertaining to the particular child being assessed; it serves as the child's file.

interface
The interface, part of the control structure, is the system component with which the user interacts.

light pen
A light pen is an input device employed with a computer graphics terminal; the pen is used to write or draw the input on the terminal's screen or tabloid.

production rules
The set of production rules is the system component which represents the experts' knowledge; the rules are an encoding of how the experts handle particular situations. Each rule specifies necessary preconditions and appropriate system actions.

production system
A production system, one appropriate model for an expert system, consists of a global database, a set of production rules and a control structure.

relative average ability
A skill is categorized as a relative average ability when, compared to the child's other abilities and skill levels, it is neither a strength nor a weakness.

relative strength
A skill is categorized as a relative strength when, compared to the child's other abilities and skill levels, it represents an area of strength.

relative weakness
A skill is categorized as a relative weakness when, compared to the child's other abilities and skill levels, it represents an area of weakness.

strength
A skill is categorized as a strength when, compared to the child's chronological peers, the child's ability is better than average.

weakness
A skill is categorized as a weakness when, compared to the child's chronological peers, the child's ability is below average.

APPENDIX B

AN EXAMPLE OF THE SYSTEM'S PERFORMANCE

Presented here is an example of the system's usage. The case is fictional, designed to illustrate as many of the system's features as possible; to demonstrate all of the expert system's capabilities would require more space than is feasible here. The entire interaction between the expert system and the user is included, along with the resulting diagnostic report and global database. The user's responses are prefixed by the prompt character '*'.

Generally, the user would not print the global database, but it is provided here for completeness. Variable names are, for the most part, self-explanatory. For those unfamiliar with LISP, 'T' represents 'TRUE' and 'NIL' indicates 'FALSE'. If a value was never assigned to a particular property list, LISP's default value is 'NIL'.

THE INTERACTION WITH THE SYSTEM:

```
"ENTER THE FILE NUMBER."
*1

"ENTER THE CHILD'S FIRST NAME"
*BILL

"ENTER THE CHILD'S SEX: M=MALE, F=FEMALE"
*M

ENTER THE CHILD'S DATE OF BIRTH.
YEAR:    *1964
MONTH:   *11
DAY:     *2
```

```
'ENTER THE REASONS FOR REFERRAL AS A LIST OF NUMBERS
E.G. (1 2 4), WHERE 1=INTELLECTUAL ASSESSMENT, 2=READING,
3=SPELLING, 4=ARITHMETIC, 5=LANGUAGE, 6=HANDWRITING,
7=BEHAVIOUR/EMOTIONAL PROBLEMS, 8=MOTOR SKILLS.'
*(2)

ENTER THE DATE ON WHICH THE CHILD WAS REFERRED.
YEAR:    *1973
MONTH:   *7
DAY:     *10

WHAT DATE WAS THE SCHOOL REPORT COMPLETED?
YEAR:    *1973
MONTH:   *7
DAY:     *11

'ENTER THE CHILD'S CURRENT GRADE AS A NUMBER OR K=KINDERGARTEN,
N=NOT IN SCHOOL, DK=INFORMATION NOT AVAILABLE.'
*2

'ENTER THE GRADES WHICH THE CHILD HAS ATTENDED, AS A LIST OF
NUMERALS E.G. (K 1 2  4).  ENTER N IF THE QUESTION IS NOT
APPROPRIATE.  ENTER DK IF THE INFORMATION IS NOT AVAILABLE.'
*(K 1 2)

'ENTER THE GRADES WHICH THE CHILD HAS REPEATED, AS A LIST OF
NUMERALS E.G. (1).  ENTER (0) IF NO GRADES HAVE BEEN REPEATED.
N=QUESTION IS NOT APPROPRIATE, DK=INFORMATION NOT AVAILABLE.'
*DK

READING:  ENTER THE GENERAL RATING COMPUTED FROM THE SCHOOL REPORT.
*4

SPELLING:  ENTER THE GENERAL RATING COMPUTED FROM THE SCHOOL REPORT.
*3.5

ARITHMETIC:
ENTER THE GENERAL RATING COMPUTED FROM THE SCHOOL REPORT.
*2

'ARE THERE PREVIOUS TEST SCORES TO BE ENTERED?'
*Y

'ENTER THE ABBREVIATED NAME OF THE TEST.'
*WISCR

'ENTER THE TYPE OF TEST E.G. ABILITY, ACHIEVEMENT, INDIVIDUAL.
USE A LIST FORMAT E.G. (ACHIEVEMENT) OR (ABILITY GROUP).'
*(ABILITY INDIVIDUAL)

ENTER THE DATE ON WHICH THE TEST WAS ADMINISTERED.
YEAR:    *1969
MONTH:   *10
DAY:     *12
```

```
'ENTER THE TYPE OF SCORE E.G. QUOTIENT, AGE, PERCENTILE,
SS (SCALED SCORE).'
*QUOTIENT

'ENTER THE TEST SCORE.'
*115

'ARE THERE PREVIOUS TEST SCORES TO BE ENTERED?'
*N

GROSS MOTOR SKILLS:
ENTER THE GENERAL RATING COMPUTED FROM THE SCHOOL REPORT.
*4

FINE MOTOR SKILLS:
ENTER THE GENERAL RATING COMPUTED FROM THE SCHOOL REPORT.
*3

'SPOKEN LANGUAGE:
ENTER THE GENERAL RATING COMPUTED FROM THE SCHOOL REPORT.'
*3.5

'WRITTEN LANGUAGE:
ENTER THE GENERAL RATING COMPUTED FROM THE SCHOOL REPORT.'
*3

WRITING:  ENTER THE GENERAL RATING COMPUTED FROM THE SCHOOL REPORT.
*3

BEHAVIOUR:  ENTER THE GENERAL RATING COMPUTED FROM THE SCHOOL REPORT.
*4

'PARENTAL ATTITUDE:
ENTER THE GENERAL RATING COMPUTED FROM THE SCHOOL REPORT.'
*1

WHAT DATE WAS THE PARENT QUESTIONNAIRE COMPLETED?
YEAR:   *1973
MONTH:  *7
DAY:    *5

'HAVE THE SIBLINGS EXPERIENCED ANY SCHOOL DIFFICULTIES?'
*N

'HAS ANY OTHER FAMILY MEMBER EXPERIENCED
 READING OR SPELLING DIFFICULTIES?'
*Y

'IS THE FAMILY SITUATION FAVOURABLE?'
*Y

'HAS THE SCHOOL ATTENDANCE BEEN POOR OR A PROBLEM?'
*N
```

```
"HAS IT EVER BEEN SUSPECTED THAT THE
CHILD HAS DEFECTIVE EYESIGHT?"
*N

"HAS THE CHILD EVER BEEN SEEN BY AN
OPTOMETRIST OR EYE SPECIALIST?"
*Y

"WHAT WAS THE RESULT?:
1 = NORMAL EYESIGHT, 2 = GLASSES, 3 = OTHER."
*1

"HAS IT EVER BEEN SUSPECTED THAT THE CHILD
HAS DEFECTIVE HEARING?"
*Y

"HAS THE CHILD EVER HAD A HEARING TEST?"
*N

"HAVE THERE BEEN OTHER MEDICAL PROBLEMS WHICH MAY
ACCOUNT FOR THE CHILD'S LEARNING DIFFICULTIES?"
*N

"IS THE CHILD NERVOUS?"
*Y

"IS THE CHILD OVER-ACTIVE?"
*N

"IS THE CHILD MOODY?"
*Y

"HAS LANGUAGE DEVELOPMENT BEEN NORMAL WITH REGARDS TO MEMORY?"
*N

"HAS LANGUAGE DEVELOPMENT BEEN NORMAL WITH REGARDS TO SYNTAX?"
*Y

"HAS THE CHILD'S LANGUAGE DEVELOPED AT A NORMAL RATE?"
*N

"DO THE CHILD'S VISUAL MOTOR SKILLS AND VISUAL
PERCEPTION APPEAR TO BE NORMAL?"
*N

"DOES THE CHILD'S AUDITORY MEMORY AND AUDITORY
PERCEPTION APPEAR TO BE NORMAL?"
*N

"DO THE CHILD'S GROSS MOTOR SKILLS APPEAR TO BE NORMAL?"
*N

"DO THE CHILD'S FINE MOTOR SKILLS APPEAR TO BE NORMAL?"
*N
```

```
'DOES THE CHILD EVER CONFUSE LEFT AND RIGHT?'
*Y

'ADMINISTER AN INDIVIDUAL ABILITY TEST SUCH AS
THE WISCR OR THE ITPA.  ENTER THE NAME OF THE TEST.'
*ITPA

ENTER THE DATE ON WHICH THE TEST WAS ADMINISTERED.
YEAR:    *1973
MONTH:  *7
DAY:    *10

GLOBAL SCORE -- PLA:
'ENTER THE TEST SCORE.'
ENTER THE YEARS, THEN THE MONTHS.
YEARS:    *N
MONTHS:  *N

VISUAL-RECEPTION:  SCALED SCORE.
'ENTER THE TEST SCORE.'
*32

AUDITORY-RECEPTION:  SCALED SCORE.
'ENTER THE TEST SCORE.'
*39

AUDITORY-ASSOCIATION:  SCALED SCORE.
'ENTER THE TEST SCORE.'
*47

VISUAL-ASSOCIATION:  SCALED SCORE.
'ENTER THE TEST SCORE.'
*45

VERBAL-EXPRESSION:  SCALED SCORE.
'ENTER THE TEST SCORE.'
*41

MANUAL-EXPRESSION:  SCALED SCORE.
'ENTER THE TEST SCORE.'
*48

GRAMMATICAL-CLOSURE:  SCALED SCORE.
'ENTER THE TEST SCORE.'
*34

VISUAL-CLOSURE:  SCALED SCORE.
'ENTER THE TEST SCORE.'
*32

AUDITORY-SEQUENTIAL-MEMORY:  SCALED SCORE.
'ENTER THE TEST SCORE.'
*37
```

```
VISUAL-SEQUENTIAL-MEMORY:  SCALED SCORE.
'ENTER THE TEST SCORE.'
*31

AUDITORY-CLOSURE:  SCALED SCORE.
'ENTER THE TEST SCORE.'
*N

SOUND-BLENDING:  SCALED SCORE.
'ENTER THE TEST SCORE.'
*N

'ADMINISTER AN INDIVIDUAL ACHIEVEMENT TEST SUCH AS THE
WIDE RANGE ACHIEVEMENT TEST (WRAT) OR THE PEABODY INDIVIDUAL
ACHIEVEMENT TEST (PIAT).  ENTER THE ABBREVIATED NAME OF THE
TEST OR 'OTHER' IF SEPARATE ACHIEVEMENT TESTS WERE USED FOR
EACH SUBJECT AREA.'
*OTHER

READING ACHIEVEMENT:
'ENTER THE ABBREVIATED NAME OF THE TEST.'
*SCHONELL

ENTER THE DATE ON WHICH THE TEST WAS ADMINISTERED.
YEAR:    *1973
MONTH:   *7
DAY:     *11

'ENTER THE TYPE OF SCORE E.G. QUOTIENT, AGE, PERCENTILE,
SS (SCALED SCORE).'
*AGE

'ENTER THE TEST SCORE.'
ENTER THE YEARS, THEN THE MONTHS.
YEARS:    *7
MONTHS:  *4

SPELLING ACHIEVEMENT:
'ENTER THE ABBREVIATED NAME OF THE TEST.'
*WRAT

ENTER THE DATE ON WHICH THE TEST WAS ADMINISTERED.
YEAR:    *1973
MONTH:   *7
DAY:     *11

'ENTER THE TYPE OF SCORE E.G. QUOTIENT, AGE, PERCENTILE,
SS (SCALED SCORE).'
*QUOTIENT

'ENTER THE TEST SCORE.'
*80

ARITHMETIC ACHIEVEMENT:
'ENTER THE ABBREVIATED NAME OF THE TEST.'
*N
```

```
ADMINISTER AN INDIVIDUAL READING COMPREHENSION TEST SUCH AS
THE NEALE ANALYSIS OF READING ABILITY (NEALE), THE DURRELL ANALYSIS
OF READING DIFFICULTY (DURRELL), OR THE GAP READING COMPREHENSION
TEST (GAP).
'ENTER THE ABBREVIATED NAME OF THE TEST.'
*NEALE

ENTER THE DATE ON WHICH THE TEST WAS ADMINISTERED.
YEAR:    *1973
MONTH:   *7
DAY:     *12

'ENTER THE TYPE OF SCORE E.G. QUOTIENT, AGE, PERCENTILE,
SS (SCALED SCORE).'
*AGE

'ENTER THE TEST SCORE.'
ENTER THE YEARS, THEN THE MONTHS.
YEARS:    *7
MONTHS:  *5


ADMINISTER A SCREENING TEST TO ASSESS THE CHILD'S LANGUAGE
SUCH AS THE NORTHWESTERN SYNTAX SCREENING TEST (NSST) OR THE
CLINICAL EVALUATION OF LANGUAGE FUNCTION (CELF).

ADMINISTER A TEST TO DETERMINE SPELLING SKILLS SUCH AS
THE TEST OF WRITTEN SPELLING (TWS) OR THE SPELLING SUBTEST
OF THE GATES-MCKILLOP READING DIAGNOSTIC TESTS (GATES-MCKILLOP).

THE CHILD'S HEARING SHOULD BE TESTED.

THE CHILD'S BEHAVIOUR SHOULD BE ASSESSED.

ADMINISTER AN INDIVIDUAL ORAL READING TEST WHICH ALLOWS
ONE TO ANALYZE DECODING ERRORS MADE IN CONTEXT, SUCH AS THE
NEALE ANALYSIS OF READING ABILITY (NEALE), THE DURRELL
ANALYSIS OF READING DIFFICULTY (DURRELL), OR THE GATES-
MCKILLOP READING DIAGNOSTIC TESTS (GATES-MCKILLOP).
'ENTER THE ABBREVIATED NAME OF THE TEST.'
*NEALE

ENTER THE DATE ON WHICH THE TEST WAS ADMINISTERED.
YEAR:    *1973
MONTH:   *7
DAY:     *12

'ENTER THE TYPE OF SCORE E.G. QUOTIENT, AGE, PERCENTILE,
SS (SCALED SCORE).'
*AGE

'ENTER THE TEST SCORE.'
ENTER THE YEARS, THEN THE MONTHS.
YEARS:    *7
MONTHS:  *8
```

```
"IS THERE MORE INFORMATION TO BE ENTERED REGARDING
THE PARAGRAPHS READ?"
*Y

"ENTER THE NUMBER OF THE PARAGRAPH?"
*1

"ENTER THE TOTAL NUMBER OF ERRORS."
*0

"IS THERE MORE INFORMATION TO BE ENTERED REGARDING
THE PARAGRAPHS READ?"
*Y

"ENTER THE NUMBER OF THE PARAGRAPH?"
*2

"ENTER THE TOTAL NUMBER OF ERRORS."
*6

"ENTER THE NUMBER OF SUBSTITUTIONS E.G. THE NUMBER
OF TIMES AN ENTIRE WORD WAS REPLACED."
*5

"ENTER THE NUMBER OF ADDITIONS E.G. THE NUMBER
OF TIMES AN ENTIRE WORD WAS ADDED."
*0

"ENTER THE NUMBER OF OMISSIONS E.G. THE NUMBER
OF TIMES AN ENTIRE WORD WAS OMITTED."
*0

"ENTER THE NUMBER OF REFUSALS E.G. THE NUMBER
OF TIMES THE CHILD WAS UNABLE TO ATTEMPT A WORD."
*0

"ENTER THE NUMBER OF REVERSALS E.G. THE NUMBER
OF TIMES AN ENTIRE WORD WAS REVERSED (E.G. SAW FOR WAS)."
*1

"IS THERE MORE INFORMATION TO BE ENTERED REGARDING
THE PARAGRAPHS READ?"
*Y

"ENTER THE NUMBER OF THE PARAGRAPH?"
*3

"ENTER THE TOTAL NUMBER OF ERRORS."
*19

"ENTER THE NUMBER OF SUBSTITUTIONS E.G. THE NUMBER
OF TIMES AN ENTIRE WORD WAS REPLACED."
*7
```

```
'ENTER THE NUMBER OF ADDITIONS E.G. THE NUMBER
OF TIMES AN ENTIRE WORD WAS ADDED.'
*2

'ENTER THE NUMBER OF OMISSIONS E.G. THE NUMBER
OF TIMES AN ENTIRE WORD WAS OMITTED.'
*0

'ENTER THE NUMBER OF REFUSALS E.G. THE NUMBER
OF TIMES THE CHILD WAS UNABLE TO ATTEMPT A WORD.'
*4

'ENTER THE NUMBER OF REVERSALS E.G. THE NUMBER
OF TIMES AN ENTIRE WORD WAS REVERSED (E.G. SAW FOR WAS).'
*5

'ENTER THE NUMBER OF SUBSTITUTIONS MADE AT THE
BEGINNING OF A WORD.'
*0

'ENTER THE NUMBER OF SUBSTITUTIONS MADE
IN THE MIDDLE OF A WORD.'
*0

'ENTER THE NUMBER OF SUBSTITUTIONS MADE AT THE
END OF A WORD.'
*1

'IS THERE MORE INFORMATION TO BE ENTERED REGARDING
THE PARAGRAPHS READ?'
*N

ADMINISTER AN INDIVIDUAL WORD ANALYSIS (PHONICS) TEST
SUCH AS THE DOMAIN DIAGNOSTIC PHONIC TESTS (DOMAIN).
'ENTER THE ABBREVIATED NAME OF THE TEST.'
*DOMAIN

ENTER THE DATE ON WHICH THE TEST WAS ADMINISTERED.
YEAR:   *1973
MONTH:  *7
DAY:    *15

'WHICH SUBTESTS WERE ADMINISTERED?'
*(1 3)


FOR EACH OF THE FOLLOWING INITIAL CONSONANTS,
ENTER THE CHILD'S ERRORS AS A LIST E.G. (B D T).  ENTER 'NIL' IF
NO ERRORS WERE MADE.
B
*NIL

C
*NIL
```

```
D
*NIL

F
*NIL

G
*NIL

H
*NIL

J
*NIL

L
*(K)

M
*NIL

N
*NIL

P
*NIL

R
*NIL

S
*NIL

T
*NIL

V
*NIL

W
*NIL


FOR EACH OF THE FOLLOWING FINAL CONSONANTS,
ENTER THE CHILD'S ERRORS AS A LIST E.G. (P D).  ENTER 'NIL IF NO
ERRORS WERE MADE.
-B
*(P P P)

-D
*(BR BR B)

-G
*NIL
```

```
-L
*NIL

-M
*NIL

-N
*(M M)

-P
*NIL

-S
*NIL

-T
*NIL

-X
*NIL


FOR EACH OF THE FOLLOWING INITIAL CONSONANT BLENDS ENTER
THE CHILD'S ERRORS AS A LIST E.G. (BR B DR).  ENTER NIL IF
NO ERRORS WERE MADE.
BL
*(B)

BR
*(B)

CH
*NIL

CL
*NIL

CR
*NIL

DR
*(D D BR)

FL
*(FE)

FR
*NIL

GL
*NIL

GR
*NIL
```

```
PL
*NIL

PR
*NIL

SH
*NIL

SL
*NIL

ST
*(S S S)

SW
*NIL

TH
*(T)

THR
*NIL

TR
*NIL


FOR EACH OF THE FOLLOWING FINAL CONSONANT BLENDS ENTER
THE CHILD'S ERRORS.
-CH
*(UK)

-CK
*NIL

-ND
*NIL

-NG
*NIL

-SH
*NIL

-ST
*NIL


FOR EACH OF THE FOLLOWING SHORT VOWELS, ENTER THE
CHILD'S ERRORS.
A
*(A-E)
```

```
E
*NIL

I
*(I-E)

O
*NIL

U
*(OE)

ADMINISTER A TEST TO ASSESS THE CHILD'S SKILLS AT
BLENDING SOUNDS TOGETHER.  AN APPROPRIATE TEST IS THE
SOUND BLENDING SUBTEST OF THE GATES-MCKILLOP READING
DIAGNOSTIC TESTS (GATES-MCKILLOP).
"ENTER THE ABBREVIATED NAME OF THE TEST."
*GATES-MCKILLOP

ENTER THE DATE ON WHICH THE TEST WAS ADMINISTERED.
YEAR:   *1973
MONTH:  *7
DAY:    *13

"ENTER THE NUMBER OF WORDS PRESENTED."
*23

"ENTER THE NUMBER OF CORRECT RESPONSES."
*13


ADMINISTER A TEST OF VISUAL PERCEPTION

ADMINISTER A TEST OF AUDITORY PERCEPTION SUCH AS THE
WEPMAN AUDITORY DISCRIMINATION TEST (WEPMAN) OR SUBTEST
FIVE OF THE DOMAIN DIAGNOSTIC PHONIC TESTS (DOMAIN).
"ENTER THE ABBREVIATED NAME OF THE TEST."
*WEPMAN

ENTER THE DATE ON WHICH THE TEST WAS ADMINISTERED.
YEAR:   *1973
MONTH:  *7
DAY:    *16

"ENTER THE Y SCORE:  THE NUMBER OF ERRORS MADE ON
PAIRS OF SAME WORDS."
*1

"ENTER THE X SCORE:  THE NUMBER OF ERRORS MADE ON
PAIRS OF DIFFERENT WORDS."
*1


GROSS MOTOR SKILLS SHOULD BE ASSESSED FURTHER.  AN
APPROPRIATE TEST MIGHT BE THE PURDUE PERCEPTUAL-MOTOR
SURVEY (PURDUE).
```

FINE MOTOR SKILLS SHOULD BE ASSESSED FURTHER. AN APPROPRIATE TEST MIGHT BE THE PURDUE PERCEPTUAL-MOTOR SURVEY (PURDUE).
NIL

THE DIAGNOSTIC REPORT:

FILE NUMBER: 1

THE ILLINOIS TEST OF PSYCHOLINGUISTIC ABILITIES

BILL'S PERFORMANCE ON THE ITPA INDICATES THE FOLLOWING:
STRENGTHS: AUDITORY-ASSOCIATION VISUAL-ASSOCIATION
MANUAL-EXPRESSION.
MAJOR STRENGTHS: AUDITORY-ASSOCIATION MANUAL-EXPRESSION.
RELATIVE STRENGTHS: AUDITORY-ASSOCIATION VISUAL-ASSOCIATION
MANUAL-EXPRESSION.
RELATIVE WEAKNESSES: VISUAL-RECEPTION VISUAL-CLOSURE
VISUAL-SEQUENTIAL-MEMORY.
MAJOR RELATIVE STRENGTH: MANUAL-EXPRESSION.
THE FOLLOWING CHANNELS PROCESSES OR LEVELS ARE A RELATIVE STRENGTH: ASSOCIATIVE-PROCESS EXPRESSIVE-PROCESS REPRESENTATIONAL-LEVEL.
THE FOLLOWING CHANNELS PROCESSES OR LEVELS ARE A RELATIVE WEAKNESS: AUTOMATIC-LEVEL.

ACHIEVEMENT

ACHIEVEMENT IN THE FOLLOWING SUBJECTS IS BELOW AVERAGE: SPELLING READING.

BILL'S READING COMPREHENSION IS POOR.
COMPREHENSION APPEARS TO BE IN LINE WITH BILL'S GENERAL READING ABILITY.
COMPREHENSION SHOULD BE ASSESSED FURTHER.

BILL'S LANGUAGE SHOULD BE ASSESSED FURTHER. AN APPROPRIATE SCREENING TEST MIGHT BE THE NORTHWESTERN SYNTAX SCREENING TEST (NSST) OR THE CLINICAL EVALUATION OF LANGUAGE FUNCTION (CELF).

BILL'S SPELLING SHOULD BE ASSESSED FURTHER.
AN APPROPRIATE TEST MIGHT BE THE TEST OF WRITTEN SPELLING (TWS) OR THE SPELLING SUBTEST OF THE GATES-MCKILLOP READING DIAGNOSTIC TESTS (GATES-MCKILLOP).

BILL'S HEARING SHOULD BE TESTED.

BILL'S BEHAVIOUR SHOULD BE ASSESSED.

THE NEALE ANALYSIS OF READING

BILL'S PERFORMANCE ON THE NEALE INDICATES THE FOLLOWING:

THE HIGH PROPORTION OF SUBSTITUTIONS OMISSIONS AND ADDITIONS MADE WHILE READING SUGGESTS THAT BILL IS RELYING ON CONTEXT CLUES.

A LARGE PROPORTION OF BILL'S READING ERRORS ARE REVERSALS.

THE DOMAIN DIAGNOSTIC PHONIC TESTS

BILL'S PERFORMANCE ON THE DOMAIN INDICATES THE FOLLOWING:

THE FOLLOWING INITIAL CONSONANTS SHOULD BE TAUGHT: L.

THE FOLLOWING FINAL CONSONANTS SHOULD BE TAUGHT: -D -B.

THE FOLLOWING INITIAL CONSONANT BLENDS SHOULD BE TAUGHT: ST DR.

AFTER THE ABOVE CONSONANT BLENDS ARE MASTERED THE FOLLOWING SHOULD BE TAUGHT: TH FL BR BL.

THE FOLLOWING FINAL CONSONANT BLENDS SHOULD BE TAUGHT: -CH.

BILL'S KNOWLEDGE OF SHORT VOWELS IS ADEQUATE.

THE FOLLOWING LIST CONTAINS SUBSTITUTIONS MADE ON THE DOMAIN. FOR EACH OF THE FOLLOWING PAIRS THE SECOND ELEMENT WAS SUBSTITUTED FOR THE FIRST MORE THAN FIFTY PERCENT OF THE TIME THAT AN ERROR WAS MADE ON THE FIRST: (ST S) (DR D).

FOR THIS PORTION OF THE DOMAIN BILL'S WORD ANALYSIS SKILLS ARE QUITE GOOD.

THE GATES-MCKILLOP READING DIAGNOSTIC TESTS

THE GATES-MCKILLOP SOUND BLENDING SUBTEST INDICATES THAT SOUND BLENDING IS A STRENGTH.

BILL'S VISUAL PERCEPTION SHOULD BE ASSESSED FURTHER.

THE WEPMAN AUDITORY DISCRIMINATION TEST

BILL'S PERFORMANCE ON THE WEPMAN INDICATE THAT BILL'S ABILITY TO DISCRIMINATE BETWEEN SIMILAR SOUNDS IS ADEQUATE.

GROSS MOTOR SKILLS SHOULD BE ASSESSED FURTHER. AN APPROPRIATE TEST MIGHT BE THE PURDUE.

FINE MOTOR SKILLS SHOULD BE ASSESSED FURTHER. AN APPROPRIATE TEST MIGHT BE THE PURDUE.

FURTHER ASSESSMENT FLAGS:
- FA-SPELLING
- FA-LANGUAGE
- FA-BEHAV-EMOT
- FA-HEARING
- FA-VIS-PERCEPTION
- FA-AUD-PERCEPTION
- FA-MOTOR-GROSS
- FA-MOTOR-FINE
- FA-COMPREHENSION
- FA-DECODING

DESCRIPTORS:

STRENGTHS:
- AUDITORY-ASSOCIATION
- VISUAL-ASSOCIATION
- MANUAL-EXPRESSION
- SOUND-BLENDING

WEAKNESSES:
- COMPREHENSION
- DECODING-IN-CONTEXT
- INITIAL-CONSONANTS
- FINAL-CONSONANTS
- INITIAL-CONSONANT-BLENDS
- FINAL-CONSONANT-BLENDS

AVERAGE ABILITIES:
- VISUAL-RECEPTION
- AUDITORY-RECEPTION
- VERBAL-EXPRESSION
- GRAMMATICAL-CLOSURE
- VISUAL-CLOSURE
- AUDITORY-SEQUENTIAL-MEMORY
- VISUAL-SEQUENTIAL-MEMORY
- SHORT-VOWELS
- AUDITORY-DISCRIMINATION

RELATIVE STRENGTHS:
- AUDITORY-ASSOCIATION
- VISUAL-ASSOCIATION
- MANUAL-EXPRESSION
- ASSOCIATIVE-PROCESS
- EXPRESSIVE-PROCESS
- REPRESENTATIONAL-LEVEL

RELATIVE WEAKNESSES:
- VISUAL-RECEPTION
- VISUAL-CLOSURE
- VISUAL-SEQUENTIAL-MEMORY
- AUTOMATIC-LEVEL
- CONTEXT
- WORD-REVERSALS

```
RELATIVE AVERAGE ABILITIES:
     AUDITORY-RECEPTION
     VERBAL-EXPRESSION
     GRAMMATICAL-CLOSURE
     AUDITORY-SEQUENTIAL-MEMORY
     VISUAL-CHANNEL
     AUDITORY-CHANNEL
     RECEPTIVE-PROCESS
     COMPREHENSION
```

THE GLOBAL DATABASE:

```
FILE NUMBER:     1


DATA STRUCTURES AND VALUES



CHILD
FIRST-NAME   BILL
BIRTH-DATE   (2 11 1964)
AGE   (8 8 9)
SEX   M



REFERRAL
REASONS   (2)
DATE   (10 7 1973)
DATESR   (11 7 1973)
DATEPQ   (5 7 1973)



SCHOOL
GRADE   2
GRADES-ATTENDED   (K 1 2)
GRADES-REPEATED   DK
POOR-ATTENDANCE   NO



FAMILY
PARENTAL-ATTITUDE   1
FAMILY-SIT-OK   T
READING-PROBLEMS   T
SIBLING-SCH-DIFF   NO
```

```
BEHAVIOUR
RATING-SR   4
MOODY   T
OVER-ACTIVE   NO
NERVOUS   T
RECOMMENDATION   REFERRAL


MOTOR
GROSS-RATING-SR   4
GROSS-RATING-PQ   NO
NAME-GROSS   N
RECOMMENDATION-GROSS   (FURTHER ASSESSMENT)
FINE-RATING-SR   3
FINE-RATING-PQ   NO
NAME-FINE   N
RECOMMENDATION-FINE   (FURTHER ASSESSMENT)


MEDICAL
OTHER   NO
VIS-SUSPECT   NO
VIS-TESTED   T
VIS-RESULT   1
VIS-RECOMMENDATION   NIL
AUD-SUSPECT   T
AUD-TESTED   NO
AUD-RESULT   NIL
AUD-RECOMMENDATION   REFERRAL


AUDITORY-PERCEPTION
RATING-PQ   NO
NAME   WEPMAN
DATE   (16 7 1973)


VISUAL-PERCEPTION
RATING-PQ   NO
NAME   N
RECOMMENDATION   (FURTHER ASSESSMENT)


ABILITY
RATING   AVERAGE
TEST-NAME   ITPA
DATE   (10 7 1973)
PLA-MA   (N N)
QUOTIENT   105
```

```
ACHIEVEMENT
RATING   N
TEST-NAME   (SEE SEPARATE TESTS)
DATE   N


SPELLING
RATING-SR   3.5
ACH-NAME   WRAT
ACH-DATE   (11 7 1973)
ACH-SCORE-TYPE-GIVEN   QUOTIENT
ACH-SCORE-GIVEN   80
ACH-SCORE-TYPE-COMPUTED   NIL
ACH-SCORE-COMPUTED   NIL
RECOMMENDATION   (FURTHER ASSESSMENT AT THE DEFINITIVE STAGE - LEVEL 2


ARITHMETIC
RATING-SR   2
ACH-NAME   N
ACH-DATE   NIL
ACH-SCORE-TYPE-GIVEN   NIL
ACH-SCORE-GIVEN   NIL
ACH-SCORE-TYPE-COMPUTED   NIL
ACH-SCORE-COMPUTED   NIL
RECOMMENDATION   NIL


WRITING
RATING-SR   3
RECOMMENDATION   NIL


LANGUAGE
SPOKEN-RATING-SR   3.5
WRITTEN-RATING-SR   3
NORMAL-RATE-OF-DEV   NO
NORMAL-DEV-SYNTAX   T
NORMAL-DEV-MEMORY   NO
RECOMMENDATION   (FURTHER ASSESSMENT AT THE DEFINITIVE STAGE - LEVEL 2


READING
RATING-SR   4
LEFT-RT-CONFUSION   T
ACH-NAME   SCHONELL
ACH-DATE   (11 7 1973)
ACH-SCORE-TYPE-GIVEN   AGE
ACH-SCORE-GIVEN   (7 4)
ACH-SCORE-TYPE-COMPUTED   QUOTIENT
ACH-SCORE-COMPUTED   84
```

```
COMPREHENSION-NAME   NEALE
COMPREHENSION-DATE   (12 7 1973)
COMPREHENSION-SCORE-TYPE-GIVEN   AGE
COMPREHENSION-SCORE-GIVEN   (7 5)
COMPREHENSION-SCORE-TYPE-COMPUTED   QUOTIENT
COMPREHENSION-SCORE-COMPUTED   85
DECODING-NAME   DOMAIN
DECODING-DATE   (15 7 1973)
DECODING-CONTEXT-NAME   NEALE
DECODING-CONTEXT-DATE   (12 7 1973)
DECODING-CONTEXT-SCORE-TYPE-GIVEN   AGE
DECODING-CONTEXT-SCORE-GIVEN   (7 8)
DECODING-CONTEXT-SCORE-TYPE-COMPUTED   QUOTIENT
DECODING-CONTEXT-SCORE-COMPUTED   88
DECODING-%-SB   NIL
DECODING-%-SM   NIL
DECODING-%-SE   NIL
DECODING-%-CONTEXT   56
DECODING-%-REVERSALS   24
DECODING-LETTER-NC   NIL
DECODING-LETTER-NS   NIL
DECODING-LETTER-SC   NIL
DECODING-LETTER-SS   NIL
SOUND-BLENDING-NAME   GATES-MCKILLOP
SOUND-BLENDING-DATE   (13 7 1973)
SOUND-BLENDING-RATING   ABOVE-AVERAGE


PHONICS
CONFUSIONS   ((ST S) (DR D))
TRUE-%-INITC   12
TRUE-%-FINALC   29
TRUE-%-INITCBLENDS   15
TRUE-%-FINALCBLENDS   4
TRUE-%-SHORTV   37
TRUE-%-LONGV   0
TRUE-%-VBLENDS   0
ERRORS-%-INITC   4
ERRORS-%-FINALC   34
ERRORS-%-INITCBLENDS   43
ERRORS-%-FINALCBLENDS   4
ERRORS-%-SHORTV   13
ERRORS-%-LONGV   0
ERRORS-%-VBLENDS   0
ERRORS-%-IC-CBL   0
ERRORS-%-FC-CBL   25
ERRORS-%-ICBL-C   80
ERRORS-%-FCBL-C   0
ERRORS-%-SV-LV   66
ERRORS-%-SV-VBL   33
ERRORS-%-LV-SV   0
ERRORS-%-LV-VBL   0
ERRORS-%-VBL-SV   0
ERRORS-%-VBL-LV   0


PREV-TESTING
TEST#   (1)
```

```
ITPA
DATE   (10 7 1973)
GLOBAL-SCORE   (N N)
SUBTEST-AVERAGE   38
VISUAL-CHANNEL-MEAN   37
AUDITORY-CHANNEL-MEAN   39
RECEPTIVE-PROCESS-MEAN   35
ASSOCIATIVE-PROCESS-MEAN   46
EXPRESSIVE-PROCESS-MEAN   44
REPRESENTATIONAL-LEVEL-MEAN   42
AUTOMATIC-LEVEL-MEAN   33


NEALE
DATE   (12 7 1973)
COMPREHENSION-SCORE-TYPE-GIVEN   AGE
COMPREHENSION-SCORE-GIVEN   (7 5)
COMPREHENSION-SCORE-TYPE-COMPUTED   QUOTIENT
COMPREHENSION-SCORE-COMPUTED   85
DECODING-CONTEXT-SCORE-TYPE-GIVEN   AGE
DECODING-CONTEXT-SCORE-GIVEN   (7 8)
DECODING-CONTEXT-SCORE-TYPE-COMPUTED   QUOTIENT
DECODING-CONTEXT-SCORE-COMPUTED   88
PARAGRAPHS-READ   (3 2 1)


DOMAIN
DATE   (15 7 1973)
SUBTESTS   (1 3)
MAJOR-UNKNOWN-INITC   NIL
UNKNOWN-INITC   (L)
MAJOR-UNKNOWN-FINALC   NIL
UNKNOWN-FINALC   (-D -B)
MAJOR-UNKNOWN-INITCBLENDS   (ST DR)
UNKNOWN-INITCBLENDS   (TH FL BR BL)
MAJOR-UNKNOWN-FINALCBLENDS   NIL
UNKNOWN-FINALCBLENDS   (-CH)
MAJOR-UNKNOWN-SHORTV   NIL
UNKNOWN-SHORTV   NIL
MAJOR-UNKNOWN-LONGV   NIL
UNKNOWN-LONGV   NIL
MAJOR-UNKNOWN-VBLENDS   NIL
UNKNOWN-VBLENDS   NIL
TOTAL-ERRORS   23
TOTAL-ERRORS-INITC   1
TOTAL-ERRORS-FINALC   8
TOTAL-ERRORS-INITCBLENDS   10
TOTAL-ERRORS-FINALCBLENDS   1
TOTAL-ERRORS-SHORTV   3
TOTAL-ERRORS-LONGV   0
TOTAL-ERRORS-VBLENDS   0
```

```
IC-CBL   0
FC-CBL   2
ICBL-C   8
FCBL-C   0
SV-LV   2
SV-VBL   1
LV-SV   0
LV-VBL   0
VBL-SV   0
VBL-LV   0


GATES-MCKILLOP
DATE   (13 7 1973)
FIRST-ATTEMPT-#PRESENTED   23
FIRST-ATTEMPT-#CORRECT   13


WEPMAN
DATE   (16 7 1973)
X-SCORE   1
Y-SCORE   1


PREVIOUS TESTING
NAME1     WISCR
TYPE1     (ABILITY INDIVIDUAL)
DATE1     (12 10 1969)
SCORE-TYPE1     QUOTIENT
SCORE1     115
SCORE-TYPE1COMPUTED     NIL
SCORE1COMPUTED     NIL


THE ITPA
VISUAL-RECEPTION     32
AUDITORY-RECEPTION     39
AUDITORY-ASSOCIATION     47
VISUAL-ASSOCIATION     45
VERBAL-EXPRESSION     41
MANUAL-EXPRESSION     48
GRAMMATICAL-CLOSURE     34
VISUAL-CLOSURE     32
AUDITORY-SEQUENTIAL-MEMORY     37
VISUAL-SEQUENTIAL-MEMORY     31
AUDITORY-CLOSURE     N
SOUND-BLENDING     N
```

```
THE NEALE
TOTAL-ERRORS3       19
SUBSTITUTIONS3       7
ADDITIONS3       2
OMISSIONS3       0
REFUSALS3      4
REVERSALS3       5
MISPRONUNCIATIONS3        1
TOTAL-SB3      0
TOTAL-SM3      0
TOTAL-SE3      1
TOTAL-ERRORS2       6
SUBSTITUTIONS2       5
ADDITIONS2       0
OMISSIONS2       0
REFUSALS2      0
REVERSALS2       1
MISPRONUNCIATIONS2        0
TOTAL-SB2      NIL
TOTAL-SM2      NIL
TOTAL-SE2      NIL
TOTAL-ERRORS1       0
SUBSTITUTIONS1       0
ADDITIONS1       0
OMISSIONS1       0
REFUSALS1      0
REVERSALS1       0
MISPRONUNCIATIONS1        0
TOTAL-SB1      0
TOTAL-SM1      0
TOTAL-SE1      0


THE DOMAIN
INITIAL CONSONANTS
B      NIL
C      NIL
D      NIL
F      NIL
G      NIL
H      NIL
J      NIL
L      (K)
M      NIL
N      NIL
P      NIL
R      NIL
S      NIL
T      NIL
V      NIL
W      NIL
```

```
FINAL CONSONANTS
-B     (P P P)
-D     (BR BR B)
-G     NIL
-L     NIL
-M     NIL
-N     (M M)
-P     NIL
-S     NIL
-T     NIL
-X     NIL
INITIAL CONSONANT BLENDS
BL     (B)
BR     (B)
CH     NIL
CL     NIL
CR     NIL
DR     (D D BR)
FL     (FE)
FR     NIL
GL     NIL
GR     NIL
PL     NIL
PR     NIL
SH     NIL
SL     NIL
ST     (S S S)
SW     NIL
TH     (T)
THR     NIL
TR     NIL
FINAL CONSONANT BLENDS
-CH     (UK)
-CK     NIL
-ND     NIL
-NG     NIL
-SH     NIL
-ST     NIL
SHORT VOWELS
A     (A-E)
E     NIL
I     (I-E)
O     NIL
U     (OE)
LONG VOWELS
A-E     NIL
I-E     NIL
O-E     NIL
U-E     NIL
VOWEL BLENDS
AI     NIL
ALL     NIL
AR     NIL
AW     NIL
EA=E-E     NIL
EA-E     NIL
```

```
EE      NIL
ER      NIL
EW      NIL
IR      NIL
OA      NIL
OI      NIL
OO      NIL
OR      NIL
OW=O-E      NIL
OW=OU      NIL
UR      NIL


'FURTHER-ASSESSMENT' FLAGS
FA-BACKGROUND      T
FA-INTELLECT      NIL
FA-ACHIEVEMENT      NIL
FA-READING      T
FA-SPELLING      T
FA-ARITHMETIC      NIL
FA-LANGUAGE      T
FA-WRITING      NIL
FA-COMPREHENSION      T
FA-DECODING      T
FA-LETTERS      NIL
FA-SOUND-BLENDING      NIL
FA-HEARING      T
FA-VISION      NIL
FA-BEHAV-EMOT      T
FA-VIS-PERCEPTION      T
FA-AUD-PERCEPTION      T
FA-MOTOR-GROSS      T
FA-MOTOR-FINE      T


DESCRIPTORS:


DESCRIPTOR-STRENGTH
     AUDITORY-ASSOCIATION
     VISUAL-ASSOCIATION
     MANUAL-EXPRESSION
     SOUND-BLENDING
DESCRIPTOR-WEAKNESS
     COMPREHENSION
     DECODING-IN-CONTEXT
     INITIAL-CONSONANTS
     FINAL-CONSONANTS
     INITIAL-CONSONANT-BLENDS
     FINAL-CONSONANT-BLENDS
DESCRIPTOR-AVERAGE
     VISUAL-RECEPTION
     AUDITORY-RECEPTION
     VERBAL-EXPRESSION
     GRAMMATICAL-CLOSURE
     VISUAL-CLOSURE
     AUDITORY-SEQUENTIAL-MEMORY
     VISUAL-SEQUENTIAL-MEMORY
     SHORT-VOWELS
     AUDITORY-DISCRIMINATION
DESCRIPTOR-REL-STRENGTH
     AUDITORY-ASSOCIATION
     VISUAL-ASSOCIATION
     MANUAL-EXPRESSION
     ASSOCIATIVE-PROCESS
     EXPRESSIVE-PROCESS
     REPRESENTATIONAL-LEVEL
DESCRIPTOR-REL-WEAKNESS
     VISUAL-RECEPTION
     VISUAL-CLOSURE
     VISUAL-SEQUENTIAL-MEMORY
     AUTOMATIC-LEVEL
     CONTEXT
     WORD-REVERSALS
DESCRIPTOR-REL-AVERAGE
     AUDITORY-RECEPTION
     VERBAL-EXPRESSION
     GRAMMATICAL-CLOSURE
     AUDITORY-SEQUENTIAL-MEMORY
     VISUAL-CHANNEL
     AUDITORY-CHANNEL
     RECEPTIVE-PROCESS
     COMPREHENSION
```

APPENDIX C

EXPERIMENTAL DATA

Twenty-four Edexc 450 files were selected as a basis for evaluating the expert system's performance. For each of the twenty-four cases, the following is included here:

1. The expert system's diagnostic report.
2. An indication of which further assessment flags and descriptors were included in the Edexc 450 diagnostic report.
3. A summary of other pertinent information included in the Edexc 450 report.
4. A comparison of the descriptors classified as relative strengths and relative weaknesses by the encoders and the expert system.

For (2) and (4), two separate versions are included, as each Edexc 450 report was examined independently by two recent graduates in Education of Exceptional Children.

Also included here are three sample Edexc 450 reports, to enable the reader to make a comparison between the style and format of the computerized reports and those of human diagnosticians. In the majority of cases, the Edexc 450 files contain a diagnostic report. Occasionally, only a remediation report is available; these generally contain only an overview of the diagnostic findings. The appropriate sections of three Edexc 450 reports are included here, with all identifying information deleted. For the first of these reports, there is also a sample encoding of the report into the expert system's descriptor classification scheme. This encoding was performed by one of the aforementioned students.

UNIVERSITY OF SASKATCHEWAN

DEPARTMENT FOR THE EDUCATION OF EXCEPTIONAL CHILDREN

DIAGNOSTIC REPORT

Grade Level: Four

Date of birth: October 3, 1963

Chronological age: 9 years 9 months

Date: July 18, 1973

W was referred because of his inablity to read despite his bright inquisitive nature. He has been at B School since April, previously attending school in Ontario. It has been decided to keep W in Year Four for the next term because of his inability to read. W has always found school difficult. His mother terms his first year as disasterous and the second year not much better. He lacks confidence in himself and in his ability to succeed. He is constantly afraid of doing the wrong thing at the wrong time. W's parents are doing a great deal to help him to become a successful responsible adult.

Diagnostic sessions were initiated on July 10, 1973.

During most testing situations, he exhibited full attention and application to his tasks and seemed relaxed and self controlled. He is persistand and determined to "get them all right (if I can)". He found humour in situations and was quick to pick up puns. However, W seemed to be tired on each of three teating days. He repeatedly yawned and stretched throughout the testing.

A. GENERAL INTERPRETATION OF TESTS ADMINISTERED

1. Illinois Test of Psycholinguistic Abilities (I.T.P.A.)

Results obtained from the I.T.P.A. were used to establish a pattern of strengths and weaknesses in the communication processes.

The sum of the raw scores on the subtest was converted to an overall Psycholinguistic Age of 9 years 6 months, just under his chronological age. He also scored a mental age of 10 years 0 months using this sum.

Raw scores and the sum of the subtests were converted to scale scores and the sum of these was divided by ten to obtain W's Mean Scale Score of 36.8.

Using subtest scale scores and comparing them to the Mean Scale Score, it is found:

STRENGTHS:

a. a substantial difference (+9) in Visual Reception at the representational level. This refers to W's ability to find a picture sementically, but not physically, identical to the stimulus picture. (eg. a trash can and a waste basket)

b. A borderline difference (+6) in Grammatic Closure at the Automatic Level. A sample question here would be "Here is a dog. Here are two ________."

c. A substantial difference (+9) in Visual Association. Here the child is asked to choose from four optional pictures the one that "goes best" with the stimulus picture.

WEAKNESSES:

a. A borderline differnce (-7.8) in Auditory Reception at the representational level. Here the child is asked to state yes or no to questions. (eg. Do ponies shave?) A low score may also be attributed to the fact that it is the first subtest administered.

b. A borderline difference (-7.8) in Auditory Memory. Here the child is asked to repeat increasingly longer series of digits in the correct sequence. (eg. 6-3-7-9-2)

c. A significan difference (-9.8) in Visual Closure. The child is asked to find as many objects, or parts of objects, as can in one minute.

Generally, W's scores at the representatioaal level; and more especially in the visual - motor channels; was higher than those tests at the automatic level.

2. READING TESTS

W showed a good knowledge of single consonant sounds on Domain Phonics. He exhibited a definite weakness in handling vowels. He knew his consonant blends fairly well. However, he often inserted extra sounds and appeared to read from first letter clues. Word attack skills are weak. He confused b and d frequently and occasionally confused sequence of letters. He would sound out each letter, but experienced difficulty in blending the sounds together.

His average reading age was 8 years 0 months. His comprehension was well above his word attack and word recognition witha a reading age of 8 years 7 months. His oral vocabulary age was even higher at 10 years 4 months.

3. ARITHMETIC

W is performing above average in this area as measured by Key Math. His grade score was 5 years 6 months. He managed all areas very well. His computation was adequate.

4. SPELLING

W's oral spelling age was 8 years 8 months. However, he tended to spell too hurridly and omitted parts of words. He often gave letters inappropriate sounds.

His written spelling age was significantly lower at 7 years 7 months. Again, his inability to to correlate sounds and letters was apparent. He also had difficulty with homonyms - sun, son; seem, seam; your, yore.

GENERAL SUMMARY

W's teachers have realized his problem and in grades 3 and 4 he was given remedial reading instruction for half an hour a day. He gained confidence with this. However, his teachers have felt that W's self image needs building as much as his language skills. Knowing his interest in, and ability to succeed at sports; his parents have enrolled him in a Summer School Sports program.

W had enoountered some problems in left-right. He was slow in establishing a dominant hand. However, now his right hand has become dominant and he has no problem distinguishing between left and right.

W has a slight speech problem similar to other members in his mother's family. However, it is insignificant enough to not necessitate a therapist. When W was a small child his speech developed early, but in attempting to form sentences, he reverted to baby talk.

As he shows higher visual subtest scores than auditory subtest scores; it is advisable to consider the teaching of sight words or word families rather than relying on the phonetic approach entirely.

His attention span is long, but tasks should be varied to keep his interest. It is imperative that small tasks he will be successful in preceed more difficult tasks. Success has been hard come by and he values it. Praise and admiration will go a long way with this boy.

As his visual sequential memory is higher than his auditory sequential memory; one should be utilized to increase the other.

W is a well-travelled child who loves to expand on your comments and supplement them with incidents from his own experiences. Since his written language is far below normal, an approach based on language experiences may be utilized.

Suggestions for remediation are included in the following points:

RECOMMENDATIONS

1. W's self image must be strengthened. Beginning remediations with lessons that include sports would be adviseable.

RECOMMENDATIONS (con'd)

2. Since he has a fear of making mistakes in reading and writing, remediation steps must be so gradual so as to not allow for mistakes. Success and achievement should be pointed out with such things as charts or stars.

3. Auditory descrimination of vowel sounds must first be taught to the point of overlearning through drills and games. Also when learning these, W should look at his won and others' mouth position for each sound. (Learn through Kinesthetic - Tactile modality as well as Auditory) Use of a mirror would be good here.

File Number:

Child's First Name: W

DESCRIPTORS:	CATEGORIES					
	S	W	A	RS	RW	RA
auditory-reception:					✓	
visual-reception:				✓		
auditory-association:						
visual-association:				✓		
verbal-expression:						
manual-expression:						
grammatical-closure:				✓		
visual-closure:					✓	
auditory-sequential-memory:					✓	
visual-sequential-memory:						
auditory-closure:						
sound-blending:						
auditory-channel:						
visual-channel:				✓		
receptive-process:						
associative-process:						
expressive-process:						
representational-level:				✓		
automatic-level:						
auditory-discrimination:						
reading:						
arithmetic:	✓					
spelling:			✓			
comprehension:			✓			
decoding-in-context:						
context:						
beginning-substitutions:						
middle-substitutions:						
ending-substitutions:						
reversals:						
naming-capital-letters:						
naming-lowercase-letters:						
capital-letter-sounds:						
lowercase-letter-sounds:						
initial-consonants:						
final-consonants:						
initial-consonant-blends:			✓			
final-consonant-blends:			✓			
short-vowels:						
long-vowels:						
vowel-blends:					✓	
initial-consonants->consonant-blends:						
final-consonants->consonant-blends:						
initial-consonant-blends->consonants:						
final-consonant-blends->consonants:						
short-vowels->long:						
short-vowels->vowel-blends:						
long-vowels->short:						
long-vowels->vowel-blends:						
vowel-blends->short:						
vowel-blends->long:						

UNIVERSITY OF SASKATCHEWAN

DEPARTMENT OF EDUCATION OF EXCEPTIONAL CHILDREN

DIAGNOSTIC REPORT

Grade Level: 3 (4 year program)
Date of Birth: 9 years, 4 months

Date: July 16, 1973

R was referred to the clinic by his principal and teacher who were concerned about his general academic achievement in school, particularily in the areas of reading and spelling. R has spent three years in school and in view of his grades D+E in reading, spelling and writing, it is suggested he take four years to complete Division one. Promotion or remaining a fourth year in Division one could depend on his program during summer school.

Diagnostic testing began on July 10, 1973. At all sessions R gave his full attention, was very cooperative and industrious. He applied himself well to most tasks; however, when he reads aloud, his voice dropped to almost a whisper, he tended to mumble and often articulation was non-existant. He definitely has a poor self-concept in this area, no doubt from successive failures. In other tasks his voice was normal, he was relaxed and a sunshiny, happy lad. R is an exceedingly polite child.

Laterality (left-right concept) appears good.

R enjoys art work and it seems evident that he has a keen observance for detail.

A. GENERAL INTERPRETATION OF TESTS ADMINISTERED

1. Illinois Test of Psycholinguistic Abilities (ITPA)

Results of the ITPA which tests language communication skills gave R a Psycholinguistic Age of 8 years 11 months. R's strengths, though not significantly strong, were evident in Manual Expression (ability to express ideas with hands, gestures), Auditory Association (draw relationships from what is heard) and Auditory Reception (auditory receptive ability). Weaknesses were border-line in Verbal Expression (ability to put one's ideas into words) with a border-line difference of (-8) and a significant weakness in Grammatic Closure (automatic habits for handling syntax and grammatic inflections.

2. Reading

R's weaknesses showed in Schonell Word Recognition (RIA). His word attack was very poor, (RA) reading age 2 years below his (CA). This was supported when Gates-McKillop Word Attack was given. R applied some phonics knowledge but he was hesitant and inconsistant. The Domain Phonics Test revealed all phonics areas to be weak. Reversals of b and d were persistant; h and n also were noted. Neale Reading Analysis shows RA to be two years below CA. R's articulation was poor, almost monitone, observances of poor punctuation and expression was nil. Poor monitoring of sounds was also significant, (man - men); both sound alike. Context clues were used but often unknown words were guessed. Gap test for silent reading revealed a discrepancy of 2 years as well. Speed and rate were very much below average.

3. Spelling

Reversals of b for d, or d for b, were noted as being consistant. Application of phonics was apparent but there was also evidence of additions of letters. Oral spelling was somewhat better. Spelling level of achievement is low due to phonetic knowledge being at a non-automatic level.

4. Writing

R   seldom used his left hand to anchor his page. Formation of some letters does not come easily to him, and many letters are not ~~found~~ formed well. Pencil was held very tightly during the writing of the Schanell Spelling Test.

5. Arithmetic

This is an Area in which R.   seems to achieve. He worked very industriously and enthusiastically here. Multiplying and division are somewhat weak. Section on Missing Elements in Key Math test shows significant weakness. Comprehension is the apparent reason.

B. SUMMARY

Since R   shows higher ~~auditory~~ visual Skills and a perfect score in Auditory Discrimination, it would appear that his spelling and reading problem should be approached through phonics. It is necessary therefore, to strengthen his phonetic knowledge to make it useful to him on an automatic level. Through his artistic nature, his desire to improve his writing may be encouraged. Verbal expression may be improved when he talks about his drawings. These are his strong points, where he shows confidence and should be used to build up his self-image and promote successful experiences in weak areas. R's   attention span is good when he is working at Arithmetic and Art. However, he often asks when he will be through when reading or at spelling.

UNIVERSITY OF SASKATCHEWAN

DEPARTMENT FOR THE EDUCATION OF EXCEPTIONAL CHILDREN

REMEDIATION REPORT

Grade Level: Grade Two-Three
Date of birth: September 13
Chronological Age: 8 years 10 months
Date of remediation: July, 1973

T was referred to the Department for the Education of Exceptional Children because of his difficulties in reading.

I Summary of Diagnosis.

T's overall performance on the Illinois Test of Psycholinguistic Abilities (which is a diagnostic test of specific cognitive abilities as well as a molar test of intelligence), indicate that his developmental abilities in communication skills are higher than his chronological age. The tests indicated a borderline strength in visual reception (which refers to T's ability to gain meaning from visual symbols), and a borderline weakness in visual memory (which refers to the ability to reproduce a sequence of non-meaningful figures from memory.)

Schonell, Neale, and Gap reading tests all indicated that T is reading approximately a year and a half below his chronological age. Spelling age scores also indicate a year and a half lag in his spelling skills.

Observations made of T's general reading ability during testing indicate that he is a word by word reader, he ignores puncuation, substitutes and omits words, reverses certain letters and some words, and there is much head movement during oral and silent reading.

The experimental data for each Edexc 450 file follows. The two encodings of each report are distinguished as follows: encoding by student number 1 is indicated by ✓ and the second encoding is marked by ✗ .

FILE NUMBER: 430

THE ILLINOIS TEST OF PSYCHOLINGUISTIC ABILITIES

RUSSELL'S PERFORMANCE ON THE ITPA INDICATES THE FOLLOWING:
WEAKNESSES: VERBAL-EXPRESSION GRAMMATICAL-CLOSURE
VISUAL-SEQUENTIAL-MEMORY.
RELATIVE STRENGTHS: AUDITORY-ASSOCIATION.

ACHIEVEMENT

RUSSELL'S ACHIEVEMENT IN THE FOLLOWING SUBJECT AREA SHOULD BE ASSESSED: ARITHMETIC.
ACHIEVEMENT IN THE FOLLOWING SUBJECTS IS BELOW AVERAGE: SPELLING READING.

RUSSELL'S READING COMPREHENSION IS POOR.
COMPREHENSION APPEARS TO BE IN LINE WITH RUSSELL'S GENERAL READING ABILITY.
COMPREHENSION SHOULD BE ASSESSED FURTHER.

RUSSELL'S LANGUAGE SHOULD BE ASSESSED FURTHER. AN APPROPRIATE SCREENING TEST MIGHT BE THE NORTHWESTERN SYNTAX SCREENING TEST (NSST) OR THE CLINICAL EVALUATION OF LANGUAGE FUNCTION (CELF).

RUSSELL'S SPELLING SHOULD BE ASSESSED FURTHER.
AN APPROPRIATE TEST MIGHT BE THE TEST OF WRITTEN SPELLING (TWS) OR THE SPELLING SUBTEST OF THE GATES-MCKILLOP READING DIAGNOSTIC TESTS (GATES-MCKILLOP).

RUSSELL'S ARITHMETIC SKILLS SHOULD BE ASSESSED FURTHER. AN APPROPRIATE TEST MIGHT BE THE KEYMATH DIAGNOSTIC ARITHMETIC TEST (KEYMATH) OR THE STANFORD DIAGNOSTIC ARITHMETIC TEST (SDAT).

RUSSELL'S BEHAVIOUR SHOULD BE ASSESSED.

THE NEALE ANALYSIS OF READING

RUSSELL'S PERFORMANCE ON THE NEALE INDICATES THE FOLLOWING:
THE HIGH PROPORTION OF SUBSTITUTIONS OMISSIONS AND ADDITIONS MADE WHILE READING SUGGESTS THAT RUSSELL IS RELYING ON CONTEXT CLUES.

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THE DOMAIN DIAGNOSTIC PHONIC TESTS

   RUSSELL'S PERFORMANCE ON THE DOMAIN INDICATES THE FOLLOWING:
   THE FOLLOWING INITIAL CONSONANTS SHOULD BE TAUGHT: B.
   THE FOLLOWING FINAL CONSONANTS SHOULD BE TAUGHT: -B.
   AFTER THE ABOVE CONSONANTS ARE MASTERED THE FOLLOWING SHOULD BE
   TAUGHT: -P -N -G.
   THE FOLLOWING INITIAL CONSONANT BLENDS SHOULD BE TAUGHT: ST PR
   PL GR GL DR CR BL.
   AFTER THE ABOVE CONSONANT BLENDS ARE MASTERED THE FOLLOWING
   SHOULD BE TAUGHT: TR TH SL FR FL CL BR.
   THE FOLLOWING FINAL CONSONANT BLENDS SHOULD BE TAUGHT: -CH.
   THE FOLLOWING SHORT VOWELS SHOULD BE TAUGHT: E.
   AFTER THE ABOVE VOWELS ARE MASTERED THE FOLLOWING SHORT VOWELS
   SHOULD BE TAUGHT: O A.
   THE FOLLOWING LONG VOWELS SHOULD BE TAUGHT: U-E O-E I-E.
   THE FOLLOWING VOWEL BLENDS SHOULD BE TAUGHT: OW=O-E OO AR ALL.
   AFTER THE ABOVE VOWEL BLENDS ARE MASTERED THE FOLLOWING SHOULD
   BE TAUGHT: OR OI OA ER AW.
   THE FOLLOWING LIST CONTAINS SUBSTITUTIONS MADE ON THE DOMAIN.
   FOR EACH OF THE FOLLOWING PAIRS THE SECOND ELEMENT WAS
   SUBSTITUTED FOR THE FIRST MORE THAN FIFTY PERCENT OF THE TIME
   THAT AN ERROR WAS MADE ON THE FIRST: (E E-E) (-CH CK)
   (ST S) (PR P) (PL P) (GL G) (-B D).
   RUSSELL IS MAKING A LARGE PROPORTION OF ERRORS ON INITIAL
   CONSONANT BLENDS.
   A LARGE PROPORTION OF THE ERRORS MADE ON INITIAL CONSONANT
   BLENDS ARE SINGLE CONSONANT SUBSTITUTIONS.
   RUSSELL IS MAKING A LARGE PROPORTION OF ERRORS ON SHORT VOWELS.
   A LARGE PROPORTION OF THE ERRORS MADE ON SHORT VOWELS ARE LONG
   VOWEL SUBSTITUTIONS.
   RUSSELL IS MAKING A LARGE PROPORTION OF ERRORS ON LONG VOWELS.
   A LARGE PROPORTION OF THE ERRORS MADE ON LONG VOWELS ARE SHORT
   VOWEL SUBSTITUTIONS.
   RUSSELL IS MAKING A LARGE PROPORTION OF ERRORS ON VOWEL BLENDS.


RUSSELL'S SOUND BLENDING SKILLS SHOULD BE ASSESSED.


FURTHER ASSESSMENT FLAGS:
     FA-SPELLING
     FA-ARITHMETIC
     FA-LANGUAGE
     FA-BEHAV-EMOT
     FA-COMPREHENSION
     FA-DECODING
     FA-SOUND-BLENDING
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DESCRIPTORS:

WEAKNESSES:
     VERBAL-EXPRESSION
     GRAMMATICAL-CLOSURE
     VISUAL-SEQUENTIAL-MEMORY
     COMPREHENSION
     DECODING-IN-CONTEXT
     INITIAL-CONSONANTS
     FINAL-CONSONANTS
     INITIAL-CONSONANT-BLENDS
     FINAL-CONSONANT-BLENDS
     SHORT-VOWELS
     LONG-VOWELS
     VOWEL-BLENDS

AVERAGE ABILITIES:
     VISUAL-RECEPTION
     AUDITORY-RECEPTION
     AUDITORY-ASSOCIATION
     VISUAL-ASSOCIATION
     MANUAL-EXPRESSION
     VISUAL-CLOSURE
     AUDITORY-SEQUENTIAL-MEMORY

RELATIVE STRENGTHS:
     AUDITORY-ASSOCIATION

RELATIVE WEAKNESSES:
     CONTEXT
     INITIAL-CONSONANT-BLENDS
     INITIAL-CONSONANT-BLENDS->CONSONANTS
     SHORT-VOWELS
     SHORT-VOWELS->LONG
     LONG-VOWELS
     LONG-VOWELS->SHORT
     VOWEL-BLENDS
RELATIVE AVERAGE ABILITIES:
     VISUAL-RECEPTION
     AUDITORY-RECEPTION
     VISUAL-ASSOCIATION
     VERBAL-EXPRESSION
     MANUAL-EXPRESSION
     GRAMMATICAL-CLOSURE
     VISUAL-CLOSURE
     AUDITORY-SEQUENTIAL-MEMORY
     VISUAL-SEQUENTIAL-MEMORY
     VISUAL-CHANNEL
     AUDITORY-CHANNEL
     RECEPTIVE-PROCESS
     ASSOCIATIVE-PROCESS
     EXPRESSIVE-PROCESS
     REPRESENTATIONAL-LEVEL
     AUTOMATIC-LEVEL
     COMPREHENSION
@
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File Number: 430 Child's First Name: Russell

DESCRIPTORS:	CATEGORIES					
	S	W	A	RS	RW	RA
auditory-reception:						
visual-reception:						
auditory-association:						
visual-association:						
verbal-expression:		✓			✗	
manual-expression:						
grammatical-closure:		✓			✗	
visual-closure:						
auditory-sequential-memory:						
visual-sequential-memory:		✓			✗	
auditory-closure:						
sound-blending:						
auditory-channel:						
visual-channel:						
receptive-process:						
associative-process:						
expressive-process:						
representational-level:						
automatic-level:						
auditory-discrimination:						
reading:						
arithmetic:			✗			
spelling:						
comprehension:			✓			
decoding-in-context:			✗			
context:						
beginning-substitutions:						
middle-substitutions:					✓	
ending-substitutions:						
reversals:						
naming-capital-letters:						
naming-lowercase-letters:						
capital-letter-sounds:						
lowercase-letter-sounds:						
initial-consonants:					✓ ✗	
final-consonants:					✓ ✗	
initial-consonant-blends:					✗	
final-consonant-blends:						
short-vowels:						
long-vowels:						
vowel-blends:						
initial-consonants->consonant-blends:					✓	
final-consonants->consonant-blends:						
initial-consonant-blends->consonants:					✓	
final-consonant-blends->consonants:						
short-vowels->long:						
short-vowels->vowel-blends:						
long-vowels->short:						
long-vowels->vowel-blends:						
vowel-blends->short:						
vowel-blends->long:						

File Number: 430 Child's First Name: Russell

FURTHER ASSESSMENT FLAGS

- FA-BEHAV-EMOT
- FA-HEARING
- FA-VISION
- × ✓ FA-AUD-PERCEPTION
- ✓ FA-VIS-PERCEPTION
- FA-MOTOR-GROSS
- × FA-MOTOR-FINE
- ✓ FA-SPELLING
- ✓ FA-ARITHMETIC
- × FA-LANGUAGE
- FA-WRITING
- ✓ FA-COMPREHENSION
- FA-DECODING
- FA-LETTERS
- FA-SOUND-BLENDING

Other Information: omission of letters

COMPARISON WITH ENCODING NUMBER 1:

Relative Strengths:

		human diagnosis	
		noted	not noted
computer-guided diagnosis	noted	0	1
	not noted	0	19

Relative Weaknesses:

		human diagnosis	
		noted	not noted
computer-guided diagnosis	noted	1	7
	not noted	4	30

COMPARISON WITH ENCODING NUMBER 2:

Relative Strengths:

		human diagnosis	
		noted	not noted
computer-guided diagnosis	noted	0	1
	not noted	0	19

Relative Weaknesses:

		human diagnosis	
		noted	not noted
computer-guided diagnosis	noted	1	7
	not noted	5	29

FILE NUMBER: 432

THE ILLINOIS TEST OF PSYCHOLINGUISTIC ABILITIES

RONELDA'S PERFORMANCE ON THE ITPA INDICATES THE FOLLOWING:
STRENGTHS: AUDITORY-SEQUENTIAL-MEMORY VISUAL-SEQUENTIAL-MEMORY.
WEAKNESSES: AUDITORY-ASSOCIATION MANUAL-EXPRESSION GRAMMATICAL-CLOSURE VISUAL-CLOSURE.
MAJOR STRENGTHS: VISUAL-SEQUENTIAL-MEMORY.
MAJOR WEAKNESSES: GRAMMATICAL-CLOSURE VISUAL-CLOSURE.
RELATIVE STRENGTHS: AUDITORY-SEQUENTIAL-MEMORY VISUAL-SEQUENTIAL-MEMORY.
RELATIVE WEAKNESSES: GRAMMATICAL-CLOSURE VISUAL-CLOSURE.
MAJOR RELATIVE STRENGTH: AUDITORY-SEQUENTIAL-MEMORY VISUAL-SEQUENTIAL-MEMORY.
MAJOR RELATIVE WEAKNESS: GRAMMATICAL-CLOSURE.

ACHIEVEMENT

RONELDA'S ACHIEVEMENT IN THE FOLLOWING SUBJECT AREA SHOULD BE ASSESSED: ARITHMETIC.
ACHIEVEMENT IN THE FOLLOWING SUBJECTS IS BELOW AVERAGE: SPELLING READING.

RONELDA'S READING COMPREHENSION IS POOR.
COMPREHENSION APPEARS TO BE IN LINE WITH RONELDA'S GENERAL READING ABILITY.
COMPREHENSION SHOULD BE ASSESSED FURTHER.

RONELDA'S LANGUAGE SHOULD BE ASSESSED FURTHER. AN APPROPRIATE SCREENING TEST MIGHT BE THE NORTHWESTERN SYNTAX SCREENING TEST (NSST) OR THE CLINICAL EVALUATION OF LANGUAGE FUNCTION (CELF).

RONELDA'S SPELLING SHOULD BE ASSESSED FURTHER.
AN APPROPRIATE TEST MIGHT BE THE TEST OF WRITTEN SPELLING (TWS) OR THE SPELLING SUBTEST OF THE GATES-MCKILLOP READING DIAGNOSTIC TESTS (GATES-MCKILLOP).

RONELDA'S ARITHMETIC SKILLS SHOULD BE ASSESSED FURTHER. AN APPROPRIATE TEST MIGHT BE THE KEYMATH DIAGNOSTIC ARITHMETIC TEST (KEYMATH) OR THE STANFORD DIAGNOSTIC ARITHMETIC TEST (SDAT).

RONELDA'S HEARING SHOULD BE TESTED.

RONELDA'S EYESIGHT SHOULD BE TESTED.

RONELDA'S BEHAVIOUR SHOULD BE ASSESSED.

THE NEALE ANALYSIS OF READING

RONELDA'S PERFORMANCE ON THE NEALE INDICATES THE FOLLOWING: THE HIGH PROPORTION OF SUBSTITUTIONS OMISSIONS AND ADDITIONS MADE WHILE READING SUGGESTS THAT RONELDA IS RELYING ON CONTEXT CLUES.

THE DOMAIN DIAGNOSTIC PHONIC TESTS

RONELDA'S PERFORMANCE ON THE DOMAIN INDICATES THE FOLLOWING:
THE FOLLOWING INITIAL CONSONANTS SHOULD BE TAUGHT: N.
THE FOLLOWING FINAL CONSONANTS SHOULD BE TAUGHT: -X.
AFTER THE ABOVE CONSONANTS ARE MASTERED THE FOLLOWING SHOULD BE TAUGHT: -D -B.
THE FOLLOWING INITIAL CONSONANT BLENDS SHOULD BE TAUGHT: GR CH BR.
AFTER THE ABOVE CONSONANT BLENDS ARE MASTERED THE FOLLOWING SHOULD BE TAUGHT: TR TH PR DR CR CL.
THE FOLLOWING FINAL CONSONANT BLENDS SHOULD BE TAUGHT: -ND.
THE FOLLOWING SHORT VOWELS SHOULD BE TAUGHT: I E A.
THE FOLLOWING LONG VOWELS SHOULD BE TAUGHT: U-E O-E I-E A-E.
THE FOLLOWING VOWEL BLENDS SHOULD BE TAUGHT: UR OW=O-E OR OI IR EW ER EE EA=E-E AW ALL AI.
AFTER THE ABOVE VOWEL BLENDS ARE MASTERED THE FOLLOWING SHOULD BE TAUGHT: OW=OU OO OA AR.
THE FOLLOWING LIST CONTAINS SUBSTITUTIONS MADE ON THE DOMAIN. FOR EACH OF THE FOLLOWING PAIRS THE SECOND ELEMENT WAS SUBSTITUTED FOR THE FIRST MORE THAN FIFTY PERCENT OF THE TIME THAT AN ERROR WAS MADE ON THE FIRST: (OW=O-E AU) (IR AR) (EW IL) (EA=E-E E) (AW OU) (ALL EL) (U-E U-E-E) (I-E E-E-E) (-ND D) (GR FR).
RONELDA IS MAKING A LARGE PROPORTION OF ERRORS ON INITIAL CONSONANT BLENDS.
A LARGE PROPORTION OF THE ERRORS MADE ON INITIAL CONSONANT BLENDS ARE SINGLE CONSONANT SUBSTITUTIONS.
A LARGE PROPORTION OF THE ERRORS MADE ON FINAL CONSONANT BLENDS ARE SINGLE CONSONANT SUBSTITUTIONS.
A LARGE PROPORTION OF THE ERRORS MADE ON SHORT VOWELS ARE LONG VOWEL SUBSTITUTIONS.
RONELDA IS MAKING A LARGE PROPORTION OF ERRORS ON LONG VOWELS.
A LARGE PROPORTION OF THE ERRORS MADE ON LONG VOWELS ARE VOWEL BLEND SUBSTITUTIONS.
RONELDA IS MAKING A LARGE PROPORTION OF ERRORS ON VOWEL BLENDS.

THE GATES-MCKILLOP READING DIAGNOSTIC TESTS

THE GATES-MCKILLOP SOUND BLENDING SUBTEST INDICATES THAT SOUND BLENDING IS A STRENGTH.

RONELDA'S VISUAL PERCEPTION SHOULD BE ASSESSED FURTHER.

FINE MOTOR SKILLS SHOULD BE ASSESSED FURTHER. AN APPROPRIATE TEST MIGHT BE THE PURDUE.

FURTHER ASSESSMENT FLAGS:
- FA-SPELLING
- FA-ARITHMETIC
- FA-LANGUAGE
- FA-BEHAV-EMOT
- FA-HEARING
- FA-VISION
- FA-VIS-PERCEPTION
- FA-MOTOR-FINE
- FA-COMPREHENSION
- FA-DECODING

DESCRIPTORS:

STRENGTHS:
- AUDITORY-SEQUENTIAL-MEMORY
- VISUAL-SEQUENTIAL-MEMORY
- SOUND-BLENDING

WEAKNESSES:
- AUDITORY-ASSOCIATION
- MANUAL-EXPRESSION
- GRAMMATICAL-CLOSURE
- VISUAL-CLOSURE
- COMPREHENSION
- DECODING-IN-CONTEXT
- INITIAL-CONSONANTS
- FINAL-CONSONANTS
- INITIAL-CONSONANT-BLENDS
- FINAL-CONSONANT-BLENDS
- SHORT-VOWELS
- LONG-VOWELS
- VOWEL-BLENDS

AVERAGE ABILITIES:
- VISUAL-RECEPTION
- AUDITORY-RECEPTION
- VISUAL-ASSOCIATION
- VERBAL-EXPRESSION

RELATIVE STRENGTHS:
- AUDITORY-SEQUENTIAL-MEMORY
- VISUAL-SEQUENTIAL-MEMORY

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RELATIVE WEAKNESSES:
     GRAMMATICAL-CLOSURE
     VISUAL-CLOSURE
     CONTEXT
     INITIAL-CONSONANT-BLENDS
     INITIAL-CONSONANT-BLENDS->CONSONANTS
     FINAL-CONSONANT-BLENDS->CONSONANTS
     SHORT-VOWELS->LONG
     LONG-VOWELS
     LONG-VOWELS->BLENDS
     VOWEL-BLENDS

RELATIVE AVERAGE ABILITIES:
     VISUAL-RECEPTION
     AUDITORY-RECEPTION
     AUDITORY-ASSOCIATION
     VISUAL-ASSOCIATION
     VERBAL-EXPRESSION
     MANUAL-EXPRESSION
     VISUAL-CHANNEL
     AUDITORY-CHANNEL
     RECEPTIVE-PROCESS
     ASSOCIATIVE-PROCESS
     EXPRESSIVE-PROCESS
     REPRESENTATIONAL-LEVEL
     AUTOMATIC-LEVEL
     COMPREHENSION
@
```

File Number: 432 Child's First Name: Ronelda

DESCRIPTORS:	CATEGORIES					
	S	W	A	RS	RW	RA
auditory-reception:						
visual-reception:						
auditory-association:		✓				
visual-association:						
verbal-expression:						
manual-expression:						
grammatical-closure:					✓ X	
visual-closure:					✓ X	
auditory-sequential-memory:	X			✓		
visual-sequential-memory:				✓ X		
auditory-closure:						
sound-blending:						
auditory-channel:						
visual-channel:						
receptive-process:						
associative-process:						
expressive-process:						
representational-level:						
automatic-level:						
auditory-discrimination:						
reading:						
arithmetic:			X			
spelling:						
comprehension:		✓			X	
decoding-in-context:						
context:						
beginning-substitutions:						
middle-substitutions:					✓ X	
ending-substitutions:					✓ X	
reversals:						
naming-capital-letters:						
naming-lowercase-letters:						
capital-letter-sounds:						
lowercase-letter-sounds:						
initial-consonants:						
final-consonants:						
initial-consonant-blends:					✓ X	
final-consonant-blends:						
short-vowels:					✓	
long-vowels:					✓	
vowel-blends:		✓ X				
initial-consonants->consonant-blends:						
final-consonants->consonant-blends:						
initial-consonant-blends->consonants:						
final-consonant-blends->consonants:						
short-vowels->long:						
short-vowels->vowel-blends:						
long-vowels->short:						
long-vowels->vowel-blends:						
vowel-blends->short:						
vowel-blends->long:						

File Number: 432 Child's First Name: Ronelda

FURTHER ASSESSMENT FLAGS

- FA-BEHAV-EMOT
- FA-HEARING
- FA-VISION
- FA-AUD-PERCEPTION
- ✓ FA-VIS-PERCEPTION
- FA-MOTOR-GROSS
- X FA-MOTOR-FINE
- ✓ FA-SPELLING
- X FA-ARITHMETIC
- FA-LANGUAGE
- FA-WRITING
- ✓ FA-COMPREHENSION
- ✓ FA-DECODING
- FA-LETTERS
- ✓ FA-SOUND-BLENDING

COMPARISON WITH ENCODING NUMBER 1:

Relative Strengths:

		human diagnosis	
		noted	not noted
computer-guided diagnosis	noted	2	0
	not noted	0	18

Relative Weaknesses:

		human diagnosis	
		noted	not noted
computer-guided diagnosis	noted	4	6
	not noted	3	29

COMPARISON WITH ENCODING NUMBER 2:

Relative Strengths:

		human diagnosis	
		noted	not noted
computer-guided diagnosis	noted	1	1
	not noted	0	18

Relative Weaknesses:

		human diagnosis	
		noted	not noted
computer-guided diagnosis	noted	3	7
	not noted	3	29

FILE NUMBER: 433

THE ILLINOIS TEST OF PSYCHOLINGUISTIC ABILITIES

DARCY'S PERFORMANCE ON THE ITPA INDICATES THE FOLLOWING:
STRENGTHS: MANUAL-EXPRESSION VISUAL-CLOSURE.
WEAKNESSES: AUDITORY-ASSOCIATION GRAMMATICAL-CLOSURE.
MAJOR STRENGTHS: MANUAL-EXPRESSION VISUAL-CLOSURE.
MAJOR WEAKNESSES: AUDITORY-ASSOCIATION.
RELATIVE STRENGTHS: MANUAL-EXPRESSION VISUAL-CLOSURE.
RELATIVE WEAKNESSES: VISUAL-RECEPTION AUDITORY-ASSOCIATION GRAMMATICAL-CLOSURE.
MAJOR RELATIVE STRENGTH: MANUAL-EXPRESSION VISUAL-CLOSURE.
MAJOR RELATIVE WEAKNESS: AUDITORY-ASSOCIATION GRAMMATICAL-CLOSURE.
THE FOLLOWING CHANNELS PROCESSES OR LEVELS ARE A RELATIVE STRENGTH: VISUAL-CHANNEL.
THE FOLLOWING CHANNELS PROCESSES OR LEVELS ARE A RELATIVE WEAKNESS: AUDITORY-CHANNEL ASSOCIATIVE-PROCESS.

ACHIEVEMENT

DARCY'S ACHIEVEMENT IN THE FOLLOWING SUBJECT AREA SHOULD BE ASSESSED: ARITHMETIC.
ACHIEVEMENT IN THE FOLLOWING SUBJECT IS BELOW AVERAGE: SPELLING.
ACHIEVEMENT IN THE FOLLOWING SUBJECT IS IN THE LOW-AVERAGE RANGE: READING.

DARCY'S READING COMPREHENSION IS POOR.
COMPREHENSION APPEARS TO BE IN LINE WITH DARCY'S GENERAL READING ABILITY.
COMPREHENSION SHOULD BE ASSESSED FURTHER.

DARCY'S LANGUAGE SHOULD BE ASSESSED FURTHER. AN APPROPRIATE SCREENING TEST MIGHT BE THE NORTHWESTERN SYNTAX SCREENING TEST (NSST) OR THE CLINICAL EVALUATION OF LANGUAGE FUNCTION (CELF).

DARCY'S SPELLING SHOULD BE ASSESSED FURTHER.
AN APPROPRIATE TEST MIGHT BE THE TEST OF WRITTEN SPELLING (TWS) OR THE SPELLING SUBTEST OF THE GATES-MCKILLOP READING DIAGNOSTIC TESTS (GATES-MCKILLOP).

DARCY'S ARITHMETIC SKILLS SHOULD BE ASSESSED FURTHER. AN APPROPRIATE TEST MIGHT BE THE KEYMATH DIAGNOSTIC ARITHMETIC TEST (KEYMATH) OR THE STANFORD DIAGNOSTIC ARITHMETIC TEST (SDAT).

DARCY'S BEHAVIOUR SHOULD BE ASSESSED.

WHEN READING WITHIN CONTEXT DARCY'S DECODING SKILLS APPEAR TO BE APPROPRIATE FOR DARCY'S AGE.

THE NEALE ANALYSIS OF READING

DARCY'S PERFORMANCE ON THE NEALE INDICATES THE FOLLOWING:
THE HIGH PROPORTION OF SUBSTITUTIONS OMISSIONS AND ADDITIONS MADE WHILE READING SUGGESTS THAT DARCY IS RELYING ON CONTEXT CLUES.

THE DOMAIN DIAGNOSTIC PHONIC TESTS

DARCY'S PERFORMANCE ON THE DOMAIN INDICATES THE FOLLOWING:
THE FOLLOWING INITIAL CONSONANTS SHOULD BE TAUGHT: S.
AFTER THE ABOVE CONSONANTS ARE MASTERED THE FOLLOWING SHOULD BE TAUGHT: P.
THE FOLLOWING FINAL CONSONANTS SHOULD BE TAUGHT: -D.
AFTER THE ABOVE CONSONANTS ARE MASTERED THE FOLLOWING SHOULD BE TAUGHT: -L -B.
THE FOLLOWING INITIAL CONSONANT BLENDS SHOULD BE TAUGHT: THR.
AFTER THE ABOVE CONSONANT BLENDS ARE MASTERED THE FOLLOWING SHOULD BE TAUGHT: ST PL GL CH BL.
THE FOLLOWING FINAL CONSONANT BLENDS SHOULD BE TAUGHT: -NG -CK -CH.
THE FOLLOWING SHORT VOWELS SHOULD BE TAUGHT: E.
THE FOLLOWING LONG VOWELS SHOULD BE TAUGHT: U-E O-E I-E.
THE FOLLOWING VOWEL BLENDS SHOULD BE TAUGHT: OW=O-E OI ER EA=E AI.
AFTER THE ABOVE VOWEL BLENDS ARE MASTERED THE FOLLOWING SHOULD BE TAUGHT: OA IR AR ALL.
THE FOLLOWING LIST CONTAINS SUBSTITUTIONS MADE ON THE DOMAIN.
FOR EACH OF THE FOLLOWING PAIRS THE SECOND ELEMENT WAS SUBSTITUTED FOR THE FIRST MORE THAN FIFTY PERCENT OF THE TIME THAT AN ERROR WAS MADE ON THE FIRST: (ER RE-E) (AI A) (O-E O) (THR TH).
A LARGE PROPORTION OF THE ERRORS MADE ON INITIAL CONSONANTS ARE CONSONANT BLEND SUBSTITUTIONS.
A LARGE PROPORTION OF THE ERRORS MADE ON INITIAL CONSONANT BLENDS ARE SINGLE CONSONANT SUBSTITUTIONS.
DARCY IS MAKING A LARGE PROPORTION OF ERRORS ON FINAL CONSONANT BLENDS.
A LARGE PROPORTION OF THE ERRORS MADE ON SHORT VOWELS ARE LONG VOWEL SUBSTITUTIONS.
DARCY IS MAKING A LARGE PROPORTION OF ERRORS ON LONG VOWELS.
A LARGE PROPORTION OF THE ERRORS MADE ON LONG VOWELS ARE SHORT VOWEL SUBSTITUTIONS.
DARCY IS MAKING A LARGE PROPORTION OF ERRORS ON VOWEL BLENDS.
A LARGE PROPORTION OF THE ERRORS MADE ON VOWEL BLENDS ARE SHORT VOWEL SUBSTITUTIONS.

DARCY'S SOUND BLENDING SKILLS SHOULD BE ASSESSED.

GROSS MOTOR SKILLS SHOULD BE ASSESSED FURTHER. AN APPROPRIATE TEST MIGHT BE THE PURDUE.

FURTHER ASSESSMENT FLAGS:
- FA-SPELLING
- FA-ARITHMETIC
- FA-LANGUAGE
- FA-BEHAV-EMOT
- FA-MOTOR-GROSS
- FA-COMPREHENSION
- FA-DECODING
- FA-SOUND-BLENDING

DESCRIPTORS:

STRENGTHS:
- MANUAL-EXPRESSION
- VISUAL-CLOSURE

WEAKNESSES:
- AUDITORY-ASSOCIATION
- GRAMMATICAL-CLOSURE
- COMPREHENSION
- INITIAL-CONSONANTS
- FINAL-CONSONANTS
- INITIAL-CONSONANT-BLENDS
- FINAL-CONSONANT-BLENDS
- SHORT-VOWELS
- LONG-VOWELS
- VOWEL-BLENDS

AVERAGE ABILITIES:
- VISUAL-RECEPTION
- AUDITORY-RECEPTION
- VISUAL-ASSOCIATION
- VERBAL-EXPRESSION
- AUDITORY-SEQUENTIAL-MEMORY
- VISUAL-SEQUENTIAL-MEMORY
- DECODING-IN-CONTEXT

RELATIVE STRENGTHS:
- MANUAL-EXPRESSION
- VISUAL-CLOSURE
- VISUAL-CHANNEL

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RELATIVE WEAKNESSES:
     VISUAL-RECEPTION
     AUDITORY-ASSOCIATION
     GRAMMATICAL-CLOSURE
     AUDITORY-CHANNEL
     ASSOCIATIVE-PROCESS
     CONTEXT
     INITIAL-CONSONANTS->BLENDS
     INITIAL-CONSONANT-BLENDS->CONSONANTS
     FINAL-CONSONANT-BLENDS
     SHORT-VOWELS->LONG
     LONG-VOWELS
     LONG-VOWELS->SHORT
     VOWEL-BLENDS
     VOWEL-BLENDS->SHORT

RELATIVE AVERAGE ABILITIES:
     AUDITORY-RECEPTION
     VISUAL-ASSOCIATION
     VERBAL-EXPRESSION
     AUDITORY-SEQUENTIAL-MEMORY
     VISUAL-SEQUENTIAL-MEMORY
     RECEPTIVE-PROCESS
     EXPRESSIVE-PROCESS
     REPRESENTATIONAL-LEVEL
     AUTOMATIC-LEVEL
     COMPREHENSION
```

File Number: 433 Child's First Name: Darcy

DESCRIPTORS:	CATEGORIES					
	S	W	A	RS	RW	RA
auditory-reception:						
visual-reception:						
auditory-association:					✓ X	
visual-association:						
verbal-expression:						
manual-expression:	✓			X		
grammatical-closure:					✓ X	
visual-closure:	✓			X		
auditory-sequential-memory:						
visual-sequential-memory:						
auditory-closure:						
sound-blending:						
auditory-channel:						
visual-channel:						
receptive-process:						
associative-process:						
expressive-process:						
representational-level:						
automatic-level:						
auditory-discrimination:						
reading:						
arithmetic:						
spelling:						
comprehension:					X	
decoding-in-context:						
context:						
beginning-substitutions:						
middle-substitutions:					✓	
ending-substitutions:						
reversals:						
naming-capital-letters:						
naming-lowercase-letters:						
capital-letter-sounds:						
lowercase-letter-sounds:						
initial-consonants:			✓			
final-consonants:						
initial-consonant-blends:						
final-consonant-blends:						
short-vowels:						
long-vowels:						
vowel-blends:						
initial-consonants->consonant-blends:						
final-consonants->consonant-blends:						
initial-consonant-blends->consonants:						
final-consonant-blends->consonants:						
short-vowels->long:						
short-vowels->vowel-blends:						
long-vowels->short:						
long-vowels->vowel-blends:						
vowel-blends->short:						
vowel-blends->long:						

File Number: 433 Child's First Name: Darcy

FURTHER ASSESSMENT FLAGS

FA-BEHAV-EMOT
FA-HEARING
FA-VISION
X FA-AUD-PERCEPTION
FA-VIS-PERCEPTION
FA-MOTOR-GROSS
FA-MOTOR-FINE
X ✓FA-SPELLING
FA-ARITHMETIC
✓FA-LANGUAGE
FA-WRITING
FA-COMPREHENSION
X FA-DECODING
FA-LETTERS
FA-SOUND-BLENDING

Other Information: difficulty discriminating /n/

COMPARISON WITH ENCODING NUMBER 1:

Relative Strengths:

		human diagnosis	
		noted	not noted
computer-guided diagnosis	noted	0	3
	not noted	0	17

Relative Weaknesses:

		human diagnosis	
		noted	not noted
computer-guided diagnosis	noted	2	12
	not noted	1	27

COMPARISON WITH ENCODING NUMBER 2:

Relative Strengths:

		human diagnosis	
		noted	not noted
computer-guided diagnosis	noted	2	1
	not noted	0	17

Relative Weaknesses:

		human diagnosis	
		noted	not noted
computer-guided diagnosis	noted	2	12
	not noted	1	27

FILE NUMBER: 434

THE ILLINOIS TEST OF PSYCHOLINGUISTIC ABILITIES

KENNETH'S PERFORMANCE ON THE ITPA INDICATES THE FOLLOWING:
WEAKNESSES: AUDITORY-ASSOCIATION VERBAL-EXPRESSION
MANUAL-EXPRESSION GRAMMATICAL-CLOSURE
VISUAL-SEQUENTIAL-MEMORY.
MAJOR WEAKNESSES: VERBAL-EXPRESSION GRAMMATICAL-CLOSURE.
RELATIVE STRENGTHS: AUDITORY-RECEPTION.
RELATIVE WEAKNESSES: VERBAL-EXPRESSION GRAMMATICAL-CLOSURE.

ACHIEVEMENT

KENNETH'S ACHIEVEMENT IN THE FOLLOWING SUBJECT AREA SHOULD BE ASSESSED: ARITHMETIC.
ACHIEVEMENT IN THE FOLLOWING SUBJECTS IS BELOW AVERAGE: SPELLING READING.

KENNETH'S READING COMPREHENSION IS POOR.
IN COMPARISON TO KENNETH'S GENERAL ACHIEVEMENT IN READING COMPREHENSION APPEARS TO BE A RELATIVE STRENGTH.
COMPREHENSION SHOULD BE ASSESSED FURTHER.

KENNETH'S LANGUAGE SHOULD BE ASSESSED FURTHER. AN APPROPRIATE SCREENING TEST MIGHT BE THE NORTHWESTERN SYNTAX SCREENING TEST (NSST) OR THE CLINICAL EVALUATION OF LANGUAGE FUNCTION (CELF).

KENNETH'S SPELLING SHOULD BE ASSESSED FURTHER.
AN APPROPRIATE TEST MIGHT BE THE TEST OF WRITTEN SPELLING (TWS) OR THE SPELLING SUBTEST OF THE GATES-MCKILLOP READING DIAGNOSTIC TESTS (GATES-MCKILLOP).

KENNETH'S ARITHMETIC SKILLS SHOULD BE ASSESSED FURTHER. AN APPROPRIATE TEST MIGHT BE THE KEYMATH DIAGNOSTIC ARITHMETIC TEST (KEYMATH) OR THE STANFORD DIAGNOSTIC ARITHMETIC TEST (SDAT).

KENNETH'S HEARING SHOULD BE TESTED.

KENNETH'S BEHAVIOUR SHOULD BE ASSESSED.

THE NEALE ANALYSIS OF READING

KENNETH'S PERFORMANCE ON THE NEALE INDICATES THE FOLLOWING:
THE HIGH PROPORTION OF SUBSTITUTIONS OMISSIONS AND ADDITIONS MADE WHILE READING SUGGESTS THAT KENNETH IS RELYING ON CONTEXT CLUES.

THE DOMAIN DIAGNOSTIC PHONIC TESTS

KENNETH'S PERFORMANCE ON THE DOMAIN INDICATES THE FOLLOWING:
THE FOLLOWING INITIAL CONSONANTS SHOULD BE TAUGHT: N.
THE FOLLOWING FINAL CONSONANTS SHOULD BE TAUGHT: -X -B.
AFTER THE ABOVE CONSONANTS ARE MASTERED THE FOLLOWING SHOULD BE TAUGHT: -S -M -D.
THE FOLLOWING INITIAL CONSONANT BLENDS SHOULD BE TAUGHT: TR SL PL DR CH.
AFTER THE ABOVE CONSONANT BLENDS ARE MASTERED THE FOLLOWING SHOULD BE TAUGHT: PR GR GL FL.
THE FOLLOWING FINAL CONSONANT BLENDS SHOULD BE TAUGHT: -NG -CH.
AFTER THE ABOVE CONSONANT BLENDS ARE MASTERED THE FOLLOWING SHOULD BE TAUGHT: -CK.
KENNETH'S KNOWLEDGE OF SHORT VOWELS IS ADEQUATE.
THE FOLLOWING LONG VOWELS SHOULD BE TAUGHT: U-E O-E I-E A-E.
THE FOLLOWING VOWEL BLENDS SHOULD BE TAUGHT: OW=OU OO OI OA IR EW ER EE EA=E-E AW ALL AI.
AFTER THE ABOVE VOWEL BLENDS ARE MASTERED THE FOLLOWING SHOULD BE TAUGHT: UR OW=O-E OR.
THE FOLLOWING LIST CONTAINS SUBSTITUTIONS MADE ON THE DOMAIN.
FOR EACH OF THE FOLLOWING PAIRS THE SECOND ELEMENT WAS SUBSTITUTED FOR THE FIRST MORE THAN FIFTY PERCENT OF THE TIME THAT AN ERROR WAS MADE ON THE FIRST: (OO OW) (OI I) (OA A) (EW E) (EE E) (AW A) (ALL ELL) (AI A) (I-E E) (A-E A) (-NG G) (-CH SH) (DR D) (-X S).
KENNETH IS MAKING A LARGE PROPORTION OF ERRORS ON INITIAL CONSONANT BLENDS.
KENNETH IS MAKING A LARGE PROPORTION OF ERRORS ON FINAL CONSONANT BLENDS.
A LARGE PROPORTION OF THE ERRORS MADE ON FINAL CONSONANT BLENDS ARE SINGLE CONSONANT SUBSTITUTIONS.
KENNETH IS MAKING A LARGE PROPORTION OF ERRORS ON LONG VOWELS.
A LARGE PROPORTION OF THE ERRORS MADE ON LONG VOWELS ARE SHORT VOWEL SUBSTITUTIONS.
KENNETH IS MAKING A LARGE PROPORTION OF ERRORS ON VOWEL BLENDS.
A LARGE PROPORTION OF THE ERRORS MADE ON VOWEL BLENDS ARE SHORT VOWEL SUBSTITUTIONS.

KENNETH'S SOUND BLENDING SKILLS SHOULD BE ASSESSED.

KENNETH'S VISUAL PERCEPTION SHOULD BE ASSESSED FURTHER.

FINE MOTOR SKILLS SHOULD BE ASSESSED FURTHER. AN APPROPRIATE TEST MIGHT BE THE PURDUE.

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FURTHER ASSESSMENT FLAGS:
     FA-SPELLING
     FA-ARITHMETIC
     FA-LANGUAGE
     FA-BEHAV-EMOT
     FA-HEARING
     FA-VIS-PERCEPTION
     FA-MOTOR-FINE
     FA-COMPREHENSION
     FA-DECODING
     FA-SOUND-BLENDING


DESCRIPTORS:

WEAKNESSES:
     AUDITORY-ASSOCIATION
     VERBAL-EXPRESSION
     MANUAL-EXPRESSION
     GRAMMATICAL-CLOSURE
     VISUAL-SEQUENTIAL-MEMORY
     COMPREHENSION
     DECODING-IN-CONTEXT
     INITIAL-CONSONANTS
     FINAL-CONSONANTS
     INITIAL-CONSONANT-BLENDS
     FINAL-CONSONANT-BLENDS
     LONG-VOWELS
     VOWEL-BLENDS

AVERAGE ABILITIES:
     VISUAL-RECEPTION
     AUDITORY-RECEPTION
     VISUAL-ASSOCIATION
     VISUAL-CLOSURE
     AUDITORY-SEQUENTIAL-MEMORY
     SHORT-VOWELS

RELATIVE STRENGTHS:
     AUDITORY-RECEPTION
     COMPREHENSION

RELATIVE WEAKNESSES:
     VERBAL-EXPRESSION
     GRAMMATICAL-CLOSURE
     CONTEXT
     INITIAL-CONSONANT-BLENDS
     FINAL-CONSONANT-BLENDS
     FINAL-CONSONANT-BLENDS->CONSONANTS
     LONG-VOWELS
     LONG-VOWELS->SHORT
     VOWEL-BLENDS
     VOWEL-BLENDS->SHORT
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RELATIVE AVERAGE ABILITIES:
     VISUAL-RECEPTION
     AUDITORY-ASSOCIATION
     VISUAL-ASSOCIATION
     MANUAL-EXPRESSION
     VISUAL-CLOSURE
     AUDITORY-SEQUENTIAL-MEMORY
     VISUAL-SEQUENTIAL-MEMORY
     VISUAL-CHANNEL
     AUDITORY-CHANNEL
     RECEPTIVE-PROCESS
     ASSOCIATIVE-PROCESS
     EXPRESSIVE-PROCESS
     REPRESENTATIONAL-LEVEL
     AUTOMATIC-LEVEL
@
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File Number: 434 Child's First Name: Kenneth

DESCRIPTORS:	CATEGORIES					
	S	W	A	RS	RW	RA
auditory-reception:	✓					
visual-reception:	✓					
auditory-association:	✓					
visual-association:	✓					
verbal-expression:					✓ X	
manual-expression:	✓					
grammatical-closure:						
visual-closure:						
auditory-sequential-memory:	✓					
visual-sequential-memory:					✓	
auditory-closure:						
sound-blending:		X				
auditory-channel:						
visual-channel:						
receptive-process:						
associative-process:						
expressive-process:						
representational-level:						
automatic-level:						
auditory-discrimination:						
reading:			X			
arithmetic:			X			
spelling:			X			
comprehension:		X				
decoding-in-context:						
context:						
beginning-substitutions:					✓	
middle-substitutions:						
ending-substitutions:						
reversals:		X			✓	
naming-capital-letters:						
naming-lowercase-letters:						
capital-letter-sounds:						
lowercase-letter-sounds:						
initial-consonants:						
final-consonants:						
initial-consonant-blends:						
final-consonant-blends:						
short-vowels:			X			
long-vowels:						
vowel-blends:		✓X				
initial-consonants->consonant-blends:						
final-consonants->consonant-blends:						
initial-consonant-blends->consonants:						
final-consonant-blends->consonants:						
short-vowels->long:						
short-vowels->vowel-blends:						
long-vowels->short:						
long-vowels->vowel-blends:						
vowel-blends->short:						
vowel-blends->long:						

File Number: 434 Child's First Name: Kenneth

FURTHER ASSESSMENT FLAGS

FA-BEHAV-EMOT
FA-HEARING
FA-VISION
FA-AUD-PERCEPTION
FA-VIS-PERCEPTION
FA-MOTOR-GROSS
FA-MOTOR-FINE
✓ FA-SPELLING
X FA-ARITHMETIC
X FA-LANGUAGE
FA-WRITING
FA-COMPREHENSION
FA-DECODING
FA-LETTERS
FA-SOUND-BLENDING

COMPARISON WITH ENCODING NUMBER 1:

Relative Strengths:

		human diagnosis	
		noted	not noted
computer-guided diagnosis	noted	0	2
	not noted	0	18

Relative Weaknesses:

		human diagnosis	
		noted	not noted
computer-guided diagnosis	noted	1	9
	not noted	3	29

COMPARISON WITH ENCODING NUMBER 2:

Relative Strengths:

		human diagnosis	
		noted	not noted
computer-guided diagnosis	noted	0	2
	not noted	0	18

Relative Weaknesses:

		human diagnosis	
		noted	not noted
computer-guided diagnosis	noted	1	9
	not noted	0	32

FILE NUMBER: 436

THE ILLINOIS TEST OF PSYCHOLINGUISTIC ABILITIES

BUTCH'S PERFORMANCE ON THE ITPA INDICATES THE FOLLOWING:
STRENGTHS: VISUAL-ASSOCIATION AUDITORY-SEQUENTIAL-MEMORY.
WEAKNESSES: VISUAL-RECEPTION VERBAL-EXPRESSION
GRAMMATICAL-CLOSURE.
MAJOR WEAKNESSES: VISUAL-RECEPTION VERBAL-EXPRESSION.
RELATIVE STRENGTHS: VISUAL-ASSOCIATION
AUDITORY-SEQUENTIAL-MEMORY.
RELATIVE WEAKNESSES: VISUAL-RECEPTION VERBAL-EXPRESSION.
MAJOR RELATIVE STRENGTH: VISUAL-ASSOCIATION
AUDITORY-SEQUENTIAL-MEMORY.
MAJOR RELATIVE WEAKNESS: VISUAL-RECEPTION VERBAL-EXPRESSION.
THE FOLLOWING CHANNELS PROCESSES OR LEVELS ARE A RELATIVE
WEAKNESS: RECEPTIVE-PROCESS.

ACHIEVEMENT

BUTCH'S ACHIEVEMENT IN THE FOLLOWING SUBJECT AREA SHOULD BE ASSESSED: ARITHMETIC.
ACHIEVEMENT IN THE FOLLOWING SUBJECTS IS BELOW AVERAGE: SPELLING READING.

COMPREHENSION SHOULD BE ASSESSED FURTHER.

BUTCH'S LANGUAGE SHOULD BE ASSESSED FURTHER. AN APPROPRIATE SCREENING TEST MIGHT BE THE NORTHWESTERN SYNTAX SCREENING TEST (NSST) OR THE CLINICAL EVALUATION OF LANGUAGE FUNCTION (CELF).

BUTCH'S SPELLING SHOULD BE ASSESSED FURTHER.
AN APPROPRIATE TEST MIGHT BE THE TEST OF WRITTEN SPELLING (TWS) OR THE SPELLING SUBTEST OF THE GATES-MCKILLOP READING DIAGNOSTIC TESTS (GATES-MCKILLOP).

BUTCH'S ARITHMETIC SKILLS SHOULD BE ASSESSED FURTHER. AN APPROPRIATE TEST MIGHT BE THE KEYMATH DIAGNOSTIC ARITHMETIC TEST (KEYMATH) OR THE STANFORD DIAGNOSTIC ARITHMETIC TEST (SDAT).

BUTCH'S BEHAVIOUR SHOULD BE ASSESSED.

BUTCH'S PHONICS SKILLS SHOULD BE ASSESSED FURTHER.

BUTCH'S SOUND BLENDING SKILLS SHOULD BE ASSESSED.

FURTHER ASSESSMENT FLAGS:
- FA-SPELLING
- FA-ARITHMETIC
- FA-LANGUAGE
- FA-BEHAV-EMOT
- FA-COMPREHENSION
- FA-DECODING
- FA-SOUND-BLENDING

DESCRIPTORS:

STRENGTHS:
- VISUAL-ASSOCIATION
- AUDITORY-SEQUENTIAL-MEMORY

WEAKNESSES:
- VISUAL-RECEPTION
- VERBAL-EXPRESSION
- GRAMMATICAL-CLOSURE
- DECODING-IN-CONTEXT

AVERAGE ABILITIES:
- AUDITORY-RECEPTION
- AUDITORY-ASSOCIATION
- MANUAL-EXPRESSION
- VISUAL-CLOSURE
- VISUAL-SEQUENTIAL-MEMORY

RELATIVE STRENGTHS:
- VISUAL-ASSOCIATION
- AUDITORY-SEQUENTIAL-MEMORY

RELATIVE WEAKNESSES:
- VISUAL-RECEPTION
- VERBAL-EXPRESSION
- RECEPTIVE-PROCESS

RELATIVE AVERAGE ABILITIES:
- AUDITORY-RECEPTION
- AUDITORY-ASSOCIATION
- MANUAL-EXPRESSION
- GRAMMATICAL-CLOSURE
- VISUAL-CLOSURE
- VISUAL-SEQUENTIAL-MEMORY
- VISUAL-CHANNEL
- AUDITORY-CHANNEL
- ASSOCIATIVE-PROCESS
- EXPRESSIVE-PROCESS
- REPRESENTATIONAL-LEVEL
- AUTOMATIC-LEVEL

File Number: 436 Child's First Name: Clement

DESCRIPTORS:	S	W	A	RS	RW	RA
auditory-reception:						
visual-reception:					✓ X	
auditory-association:						
visual-association:	✓			X		
verbal-expression:					✓ X	
manual-expression:						
grammatical-closure:						
visual-closure:						
auditory-sequential-memory:				✓ X		
visual-sequential-memory:					X	
auditory-closure:						
sound-blending:		✓				
auditory-channel:					X	
visual-channel:				X		
receptive-process:						
associative-process:						
expressive-process:						
representational-level:						
automatic-level:						
auditory-discrimination:			✓		X	
reading:						
arithmetic:			X			
spelling:						
comprehension:						
decoding-in-context:						
context:						
beginning-substitutions:		X				
middle-substitutions:						
ending-substitutions:		X				
reversals:		X				
naming-capital-letters:						
naming-lowercase-letters:		✓				
capital-letter-sounds:						
lowercase-letter-sounds:		X				
initial-consonants:						
final-consonants:						
initial-consonant-blends:						
final-consonant-blends:						
short-vowels:						
long-vowels:						
vowel-blends:						
initial-consonants->consonant-blends:						
final-consonants->consonant-blends:						
initial-consonant-blends->consonants:						
final-consonant-blends->consonants:						
short-vowels->long:						
short-vowels->vowel-blends:						
long-vowels->short:						
long-vowels->vowel-blends:						
vowel-blends->short:						
vowel-blends->long:						

File Number: 436 Child's First Name: Clement

FURTHER ASSESSMENT FLAGS

FA-BEHAV-EMOT
FA-HEARING
FA-VISION
X FA-AUD-PERCEPTION
X ✓ FA-VIS-PERCEPTION
FA-MOTOR-GROSS
FA-MOTOR-FINE
X ✓ FA-SPELLING
X ✓ FA-ARITHMETIC
✓ FA-LANGUAGE
X ✓ FA-WRITING
FA-COMPREHENSION
X FA-DECODING
FA-LETTERS
FA-SOUND-BLENDING

COMPARISON WITH ENCODING NUMBER 1:

Relative Strengths:

computer-guided diagnosis	human diagnosis: noted	human diagnosis: not noted
noted	1	1
not noted	0	18

Relative Weaknesses:

computer-guided diagnosis	human diagnosis: noted	human diagnosis: not noted
noted	2	1
not noted	0	39

COMPARISON WITH ENCODING NUMBER 2:

Relative Strengths:

computer-guided diagnosis	human diagnosis: noted	human diagnosis: not noted
noted	2	0
not noted	1	17

Relative Weaknesses:

computer-guided diagnosis	human diagnosis: noted	human diagnosis: not noted
noted	2	1
not noted	3	36

The remainder of Appendix C and all of Appendix D have been removed in order to reduce the number of pages in the current document.

APPENDIX E

DOCUMENTATION FOR THE SCHOOL REPORT AND PARENT QUESTIONNAIRE

There are several versions of the Institute of Child Guidance and Development's School Report; each edition provides the necessary information for levels one and two of the Retrospective stage. Not all of the data contained in the School Report is requested by the expert system.

When the system asks for a numerical rating of the child's skills, the rating is to be computed from the School Report. To accomplish this, each relevant response on the School Report is converted into a numerical rating: A=1 (very good), B=2, C=3, D=4, E=5 (very poor). The average of all appropriate items is then computed, and supplied to the expert system.

Attached are the appropriate sections of the most recent edition of the School Report. To illustrate the numerical calculations, the compacted ratings for the attached School Report follow.

Skill	Numerical version of the teacher's responses	Approximate average to be supplied to the expert system
motor-gross	1 2 3 3 2 1	2.0
motor-fine	1 2 2 2	1.7
language	4 4 5 5 3	4.0
reading	3 4 5	4.0
spelling	2 3	2.5
written expression	1 3 3 1	2.0
mathematics	2 3 2	2.3
behaviour	1 2 3 5 5 5	3.5
parental attitudes	1 1 1 2	1.3

All other information to be obtained from the School Report can be entered directly, without any pre-analysis.

A copy of the Parent Questionnaire is also attached. To answer the expert system's questions at level three of the Retrospective stage may require examining several items on the Parent Questionnaire. The following is a list of the system's questions and the associated Parent Questionnaire item numbers:

	Parent Questionnaire item number(s)
Have the siblings experienced any school difficulties?	9
Has any other family member experienced reading or spelling difficulties?	55
Is the family situation favourable?	23-24
Has the school attendance been poor or a problem?	10-12
Has it ever been suspected that the child has defective eyesight?	13
Has the child ever been seen by an optometrist or eye specialist?	14
What was the result?	15
Has it ever been suspected that the child has defective hearing?	16
Has the child ever had a hearing test?	17
What was the result?	18
Have there been other medical problems which may account for the child's learning difficulties?	20-22, 31-34
Is the child nervous?	25-29
Is the child over-active?	35-36

Is the child moody?	37
Has language development been normal with regards to memory?	44-45
Has language development been normal with regards to syntax?	43-44
Has the child's language developed at a normal rate?	39-44
Do the child's visual motor skills and visual perception appear to be normal?	46-47
Does the child's auditory memory and auditory perception appear to be normal?	48
Do the child's gross motor skills appear to be normal?	49
Do the child's fine motor skills appear to be normal?	46
Does the child ever confuse left and right?	54

Instead of averaging responses, as on the School Report, an adverse response to any of the specified Parent Questionnaire questions means the corresponding system item should also be answered with an adverse response. (Adverse responses for the system's questions are noted in Section 4.5.3.) Hence, converting the answers on the Parent Questionnaire into reponses for the system is straightforward.

CONDENSED SCHOOL REPORT

	V. Good			V. poor	
	A	B	C	D	E
Gross Motor Skills					
Poor body balance, e.g. hopping	X				
Difficulty in imitating movement patterns as demonstrated in Phys Ed.		X			
Clumsy movements, e.g. trips easily, bumps into objects			X		
Poor ability to skip			X		
Poor ability to jump over a rope or other obstacle		X			
Does not walk, run, in a smooth, rhythmical fashion	X				
Fine motor skills					
Difficulty in cutting with scissors, for age	X				
Difficulty in forming letters or numerals as compared with peers		X			
Drawings consistently poor		X			
Difficulty with rapid finger movements, e.g. touching each finger in turn with thumb repeatedly		X			
Language Development					
Ability to:					
understand spoken vocabulary?				X	
use words appropriately?				X	
use meaningful sentences?					X
tell a short story?					X
recall information generally (e.g. simple orders, short sentences)?			X		
Reading					
Ability in:					
silent reading			X		
oral reading				X	
reading expression					X
Spelling					

CONDENSED SCHOOL REPORT

	V. Good			V. poor	
	A	B	C	D	E
ability in: dictation		X			
application in written work			X		
Written Expression evaluate:					
completeness of description	X				
sequencing of ideas			X		
use of complete sentences			X		
grammatical accuracy	X				
Mathematics ability in:					
math readiness (i.e. number concepts, counting, etc.)		X			
computation (i.e. symbols, addition, etc.)			X		
application (i.e. problem solving, time, measurement, money)		X			
Motivational/Behavioural Development How well does the student:					
accept school work?	X				
persevere in work?		X			
pay attentionn during instruction/assignments?			X		
complete work consistently?					X
show consistent daily behaviours?					X
interact with age peers?					X
Parental Attitudes How well do the parents:					
co-operate with the school?	X				
accept the student's learning difficulties?	X				
accept the student himself?	X				
help with school work at home?		X			

PARENT QUESTIONNAIRE

1. Name of child (please print) ______________________________

2. Address ________________________ 3. Phone __________

4. School ________________________ 5. Grade __________

6. Date of birth __________________ 7. Age ____ years ____ months

8. FAMILY

Father's name __________________ Occupation ______________

Mother's name __________________ Occupation ______________

9. Brothers and Sisters

First name	Date of birth	School progress (e.g. very quick, some difficulties, generally slow).
____________	_________	______________
____________	_________	______________
____________	_________	______________
____________	_________	______________
____________	_________	______________

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	PLEASE ADD EXTRA COMMENTS IF YOU WISH
10. How old was s/he when s/he began kindergarten?	_______ years _______ months
11. Has s/he had any long absences from school? (For example, two weeks or longer?)	Yes : No
12. Has s/he tended to have frequent short absences?	Yes : No
13. Have you ever thought that s/he might not be able to see properly?	Yes : No
14. Has s/he ever had her/his eyes tested?	Yes : No
15. If the answer to question 14 is "yes", what did the doctor or optometrist report?	a) Nothing wrong with eyes. b) Glasses needed. c) Other (please give details): ______________________ ______________________
16. Have you ever thought that s/he might not be able to hear properly?	Yes : No
17. Has s/he ever had her/his hearing tested?	Yes : No
18. If the answer to question 17 is "yes", what was the result of the test?	a) Nothing wrong with hearing. b) Hearing aid needed. c) Other (please give details): ______________________ ______________________
19. Is s/he a leader or a follower?	Leader : Follower : Both
20. Has s/he ever been kept in hospital?	Yes : No
21. If the answer to question 20 was "yes", how was s/he at the time?	_______ years _______ months

22. If separated from parents at all during pre-school years, did s/he seem different in any way after separation? (For example, more clinging? more affectionate? more indifferent to parent(s)?)	Yes : No
23. Are both parents living?	Yes : No
24. If so, are parents living together?	Yes : No
25. Does s/he have nightmares or a fear of the dark?	Yes : No
26. Does s/he have any unusual fears?	Yes : No
27. Is s/he afraid of making mistakes at home?	Yes : No
28. Is s/he afraid of making mistakes at school?	Yes : No
29. Does s/he show anxiety or depression outside of school?	Yes : No
30. Does s/he go to great lengths to attract attention?	Yes : No
31. Was s/he a full-term (nine months) baby?	Yes : No
32. What was her/his weight at birth?	____________
33. Was there any mention of toxemia, (kidney trouble) during pregnancy?	Yes : No
34. Was there any mention of anoxia (interruption to her/his oxygen supply) at birth?	Yes : No
35. Is s/he over-active?	Yes : No
36. Was s/he overactive before s/he was born?	Yes : No
37. Does s/he change moods quickly (for example, from shyness to aggressiveness, from depression to high spirits)?	Yes : No
38. Does s/he concentrate on what s/he is doing?	Yes : No
39. At what age did s/he speak (apart from "da" or "ma")?	_______ years __________ months
40. At what age was her/his speech (i.e. two or more continuous words) intelligible to persons other than mother?	_______ years __________ months
41. Was her/his speech still immature at the age of four or five (i.e. at, or just before starting kindergarten? For example, "fink" for "think"; "dat" for "that". Referring to herself/himself by name rather than "I" or "me".)	Yes : No
42. Has s/he had speech therapy or speech correction?	Yes : No
43. Has s/he ever mixed up parts of words, or the order of words in a sentence? For example, "flutterby" for "butterfly"; "hopgrasser" for "grasshopper"; "weeks of the day" for "days of the week".	Yes : No
44. After the age of about 3½ or so, did s/he still tend to miss out words? (For example, "I going school".)	Yes : No
45. Did s/he constantly ask you to repeat what you had said, so that the procedure became more or less automatic?	Yes : No
46. Can s/he print her/his name?	Yes : No : I Don't Know
47. If so, does s/he jumble or reverse any letters?	Yes : No : I Don't Know
48. Can s/he remember a short message exactly? For example, a telephone number?	Yes : No : I Don't Know
49. Has s/he been subject to more than her/his fair share of falls?	Yes : No : I Don't Know

50. Is s/he left-handed?	Yes	No	I Don't Know
51. Does s/he kick with her/his left foot?	Yes	No	I Don't Know
52. Can s/he use either hand to do things?	Yes	No	I Don't Know
53. Has s/he *ever* been left-handed or ambidextrous?	Yes	No	I Don't Know
54. Has s/he ever had difficulty in telling left from right? (For example, when following directions, turning taps or handles.)	Yes	No	I Don't Know

55. Have any other members of the family had difficulty with reading or spelling?

______ Mother
______ Father
______ Grandmother (Mother's mother)
______ Grandmother (Father's mother)
______ Grandfather (Mother's father)
______ Grandfather (Father's father)
______ Brother(s)
______ Sister(s)
______ Other (specify): ______
______
______

Any additional comments:

______

Signature of person who provided the information ______

Relationship to child ______

Date ______

UNIVERSITY OF SASKATCHEWAN

DEPARTMENT OF COMPUTATIONAL SCIENCE

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